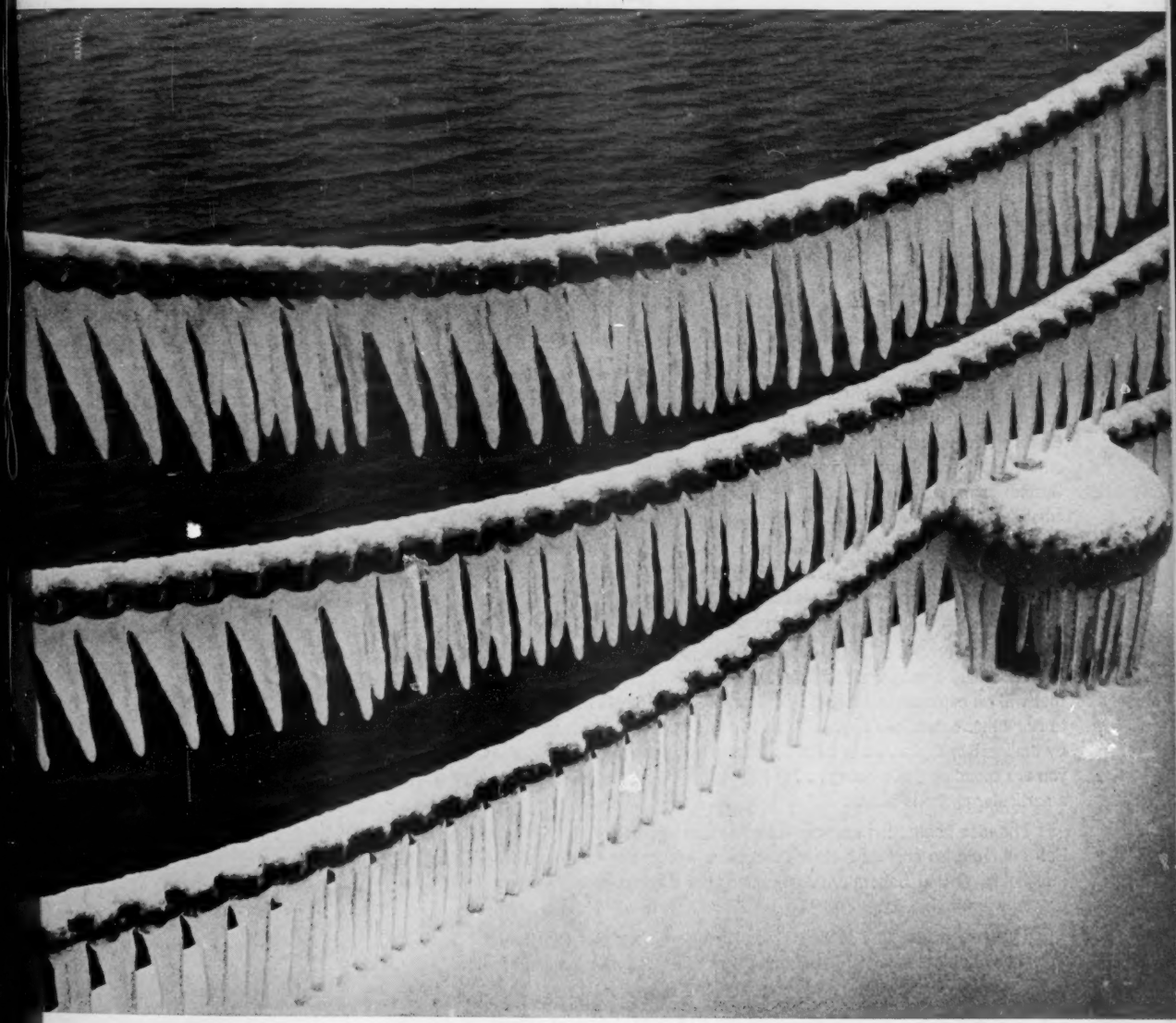
INDEX ISSUE
M. Thompson

SCIENCE

30 December 1960
Vol. 132, No. 3444

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE



Index Issue

A HISTORIC TELEPHONE EXPERIMENT BEGINS IN AN ILLINOIS TOWN

New technology brings the dream of an electronic central office to reality . . . foreshadows new kinds of telephone service.

Today, the science of communications reaches dramatically into space, bouncing messages off satellites. But an equally exciting frontier lies closer to home. Bell Telephone Laboratories engineers have created a revolutionary new central office. At Morris, Illinois, an experimental model of it has been linked to the Bell System communications network and is being tried out in actual service with a small group of customers.

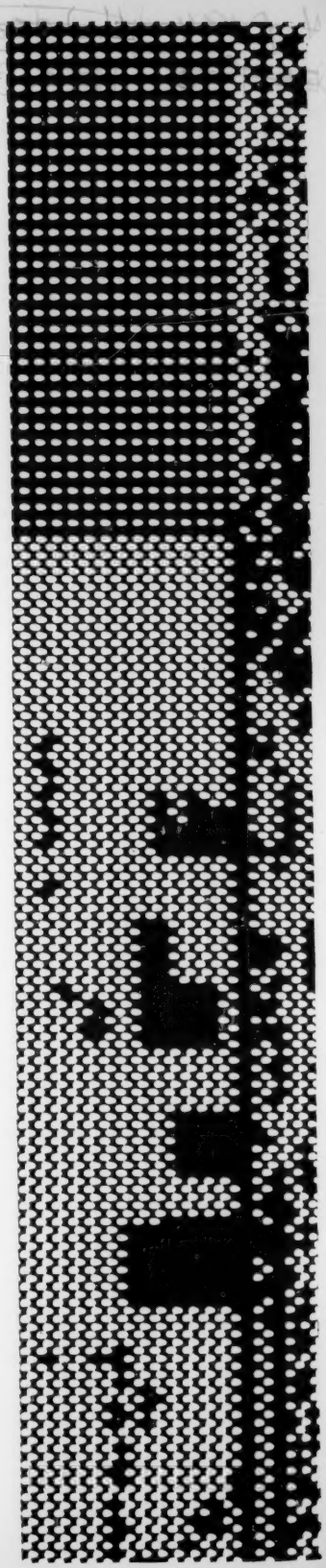
This is a special electronic central office which does not depend on mechanical relays or electromagnets. A photographic plate is its permanent memory. Its "scratch pad," or temporary memory, is a barrier grid storage tube. Gas-filled tubes make all connections. Transistor circuits provide the logic.

The new central office is versatile, fast and compact. Because it can store and use enormous amounts of information, it makes possible new kinds of services that will be explored in Morris. For example, some day it may be feasible for you to ring other extensions in your home . . . to dial people you frequently call merely by dialing two digits . . . to have your calls transferred to a friend's house where you are spending the evening . . . to have other numbers called in sequence when a particular phone is busy.

The idea behind the new central office was understood 20 years ago, but first Bell Laboratories engineers had to create new technology and devices to bring it into being. A Bell Laboratories invention, the transistor, is indispensable to its economy and reliability.

This new experiment in switching technology is another example of how Bell Telephone Laboratories works to improve your Bell communications services.

BELL TELEPHONE LABORATORIES
World center of communications research and development



Part of a memory plate of the new electronic central office is shown at right (enlarged 8 times). Spots are coded instructions which guide the system in handling calls and keeping itself in top operating form. Over two million spots are required. Logic and memory are physically separated in the machine, so new functions can be easily added. The experiment is being conducted in co-operation with the Illinois Bell Telephone Company and the Western Electric Company.

AT LAST! A SYRINGE THAT IS GAS TIGHT

Now you can handle gas in a syringe without fear of leakage. The Hamilton Gas Tight Syringe uses a stainless steel plunger coated with Teflon*, and a Teflon* gasket tip. The result is a smooth, firm plunger movement, and *no leakage to three atmospheres*. The Gas Tight Syringe is ideal for gas chromatography. It is also useful for pipetting corrosive liquids, or liquids which normally cement the syringe plunger to the barrel.

*Tetrafluoroethylene Polymer (DuPont)

- **Graduation of scale accurate to ±1%**
- **Calibrated in milliliters at 20° C**
- **Plungers interchangeable**
- **Teflon* coated plunger, with Teflon* gasket tip**
- **Patent Pending**
- **0.10, 0.25, 0.50, and 1.0 ml capacity models—$19.00**
- **2.5, 5, and 10 ml capacity models—$20.00**

***Order direct*... also available through your supply house.**

Write today for a brochure describing Hamilton's complete line of precision measuring equipment. Price list is included.

HAMILTON COMPANY, INC.

PRECISION MEASURING EQUIPMENT
FOR CLINICAL AND CHEMICAL RESEARCH

Hamilton Company, Inc.
P..O Box 307-K
Whittier, California

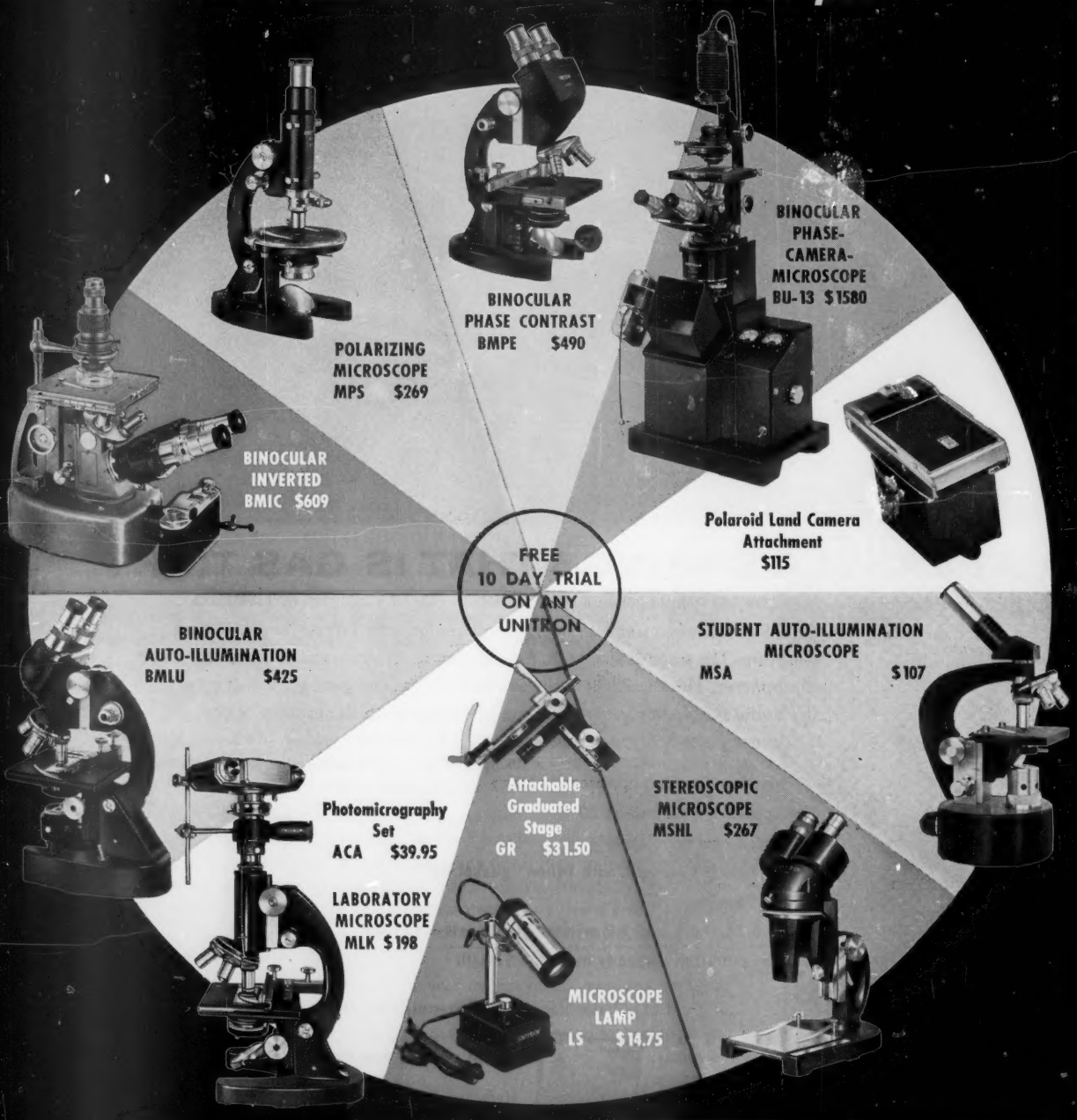
Send me a copy of your equipment brochure.

Name_____

Attach to company letterhead and mail

SCIENCE is published weekly by the AAAS. 1515 Massachusetts Ave., NW, Washington 5, D.C. Second-class postage paid at Washington, D.C.; and additional mailing office. Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢.

In the Laboratory . . . where optical quality counts . . . the trend is to UNITRON Microscopes



UNITRON offers an extensive line of Laboratory Microscopes & Accessories for Research, Industry and Education. Illustrated is a partial selection for biology, medicine, chemistry and related fields. UNITRON also has companion instruments for the metalworking industries.

Noted for optical quality . . . advanced optical and mechanical design . . . unique and convenient operational features . . . long wearing construction . . . attractive budget prices which include basic optics . . . these, together with years of proven instrument performance, are the reasons why . . .

THE TREND IS TO UNITRON!

UNITRON

INSTRUMENT COMPANY • MICROSCOPE SALES DIV.
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Please rush UNITRON's Microscope Catalog 4-J-4

Name_____

Company_____

Address_____

City_____ State_____

30 December 1960, Volume 132, Number 3444

SCIENCE

Editorial A Small Note of Cheer 1911

Articles The Indispensable Tools of Science: *P. E. Klopsteg* 1913
Instruments are unifying elements which help self-centered disciplines shed their isolationism.

Research on Handling Scientific Information: *H. L. Brownson* 1922
Improvements in communication and information handling contribute to scientific progress.

Book Reviews L. F. Richardson's *Arms and Insecurity* and *Statistics of Deadly Quarrels*, reviewed by *P. Kecskemeti*; other reviews 1931

Science in the News United States Assistance to Latin America; Four Major AAAS Awards Presented at AAAS New York Meeting 1936

Reports International Geophysical Calendar for 1961: *A. H. Shapley* 1941

Suppressive Effects of 2-Thiouracil on Differentiation and Flowering in *Cannabis sativa: J. Heslop-Harrison* 1943

Learned Behavior of Rhesus Monkeys following Neonatal Bilateral Prefrontal Lobotomy: *K. Akert* et al. 1944

Departments Letters from *J. Autian; P. J. Burke* 1910

Forthcoming Events; New Products 1947

Cover Ice formed during a winter storm on the chain railings at the U.S. Coast Guard lighthouse in Milwaukee harbor. [G. Koshollek, Jr., Milwaukee, Wis.]

SPRAGUE-DAWLEY, INC.

Pioneers in the development of the STANDARD LABORATORY RAT.

We are completing another new modern colony which will double our present production.

The new colony building contains every device to insure continuous production and shipment of guaranteed Sprague-Dawley strain albino rats.

Increased orders from our present customers and orders from new customers will be accepted as production builds up.

OUR PLEDGE: Our insistence on the highest possible quality will never be sacrificed to quantity.

Price list will be mailed upon request.

SPRAGUE-DAWLEY, INC.

P.O. Box 2071

Madison, Wisconsin

Try UNITRON'S new POLARIZING MICROSCOPE

The Model MPS is a precision instrument designed to meet the exacting requirements of science, education and industry. Ideal for work in chemistry, crystallography, biology, as well as the technology of paper, glass, textiles and petroleum.

- Eyepieces: 5X (micro.), 10X (cross.)
- Objectives: 4X, 10X, 40X, achromatic, strain-free, centerable
- Nosepiece: quick-change type
- Substage condenser: focusable, 3-lens, swing-out top mount, iris diaphragm
- Polaroid polarizer: rotatable 360°
- Polaroid analyzer: in sliding mount
- Bertrand lens: centerable
- Stage: 115mm diameter, revolves 360°, reads to 6' with vernier
- 2 Compensators: quarter-wave plate and first order red plate
- Focusing: both coarse and fine

FREE TEN-DAY TRIAL

Quantity prices on three or more

Accessory mechanical stage $14.75

$269 fob Boston

UNITRON

INSTRUMENT COMPANY • MICROSCOPE SALES DIV.
66 NEEDHAM ST., NEWTON HIGHLANDS 61, MASS.

Please rush UNITRON's Microscope Catalog 4-J-0

Name_____

Company_____

Address_____

City_____ State_____

Letters

The Pharmacist and Poison Control

As a pharmaceutical educator and research worker I was delighted to read the editorial "Middle ground" [*Science* **132**, 1221 (28 Oct. 1960)] concerning the excellent outcome of the poison control center concept, which has now spread throughout the United States. I feel, however, that you have left out a very important group of people who must daily supply information on poisons and whose acts, even though not documented, have contributed materially to saving many lives. These dedicated public health workers are the pharmacists in retail practice, hospital pharmacy, and industry. In fact, in many communities it has been the drive of the community pharmacist that has led to the setting up of an adequate center.

Furthermore, because of the pharmacist's particular background in the physical and biological sciences, which includes an exhaustive course in pharmacology, he seems well equipped to initiate and guide in the establishment and operation of a poison control center.

Schools of pharmacy are now including subject matter associated with poison control centers as a further service that the pharmacist can perform for his community in conjunction with the medical practitioner. Also, it should be kept in mind that many of the ingredients needed for poison control are part of the stock of drugs and chemicals that a well-organized pharmacy carries.

I do not wish to detract from the recognition accorded any other group in this very important public health service, but I do want to have it known that pharmacy is contributing materially to the over-all program.

JOHN AUTIAN

College of Pharmacy,
University of Texas, Austin

Nomenclature of Biological Devices

Without wishing to detract from the importance of van Bergeijk's ingenious proposal for naming devices that simulate biological functions [*Science* **132**, 1248 (28 Oct. 1960)], I would like to point out one serious fault in his proposal. This is that it confuses two quite different classes of such devices. On the one hand there are those devices whose purpose is chiefly prosthetic, while on the other there are those which are of interest in scientific or technological investigation. The latter are often made to have a type of isomorphism with natural biological systems, while the former must replace such systems to some extent in function.

Devices that are used to replace biological systems, either temporarily or permanently, are truly artificial organs and should be named as such. A natural way to name these devices is to use the Latin prefix *art-* (or *arti-*), which suggests artifice or something fashioned, together with the Latin name of the organ replaced. Thus, *articor*, *artipulmocor*, and *artiren* are suggestive of the purposes of the devices that they might name. (Let us hope that some day there will be an *artoculus*.)

One need not insist on the full nominative singular of the Latin name of the organ. Rather, one can construct a modified form, as the Romans themselves might have done—for example, *artiman* instead of *artimanus* and *artihep* for a possible artificial liver.

In case a Latin name is not available or the use of one would be forced, the Greek name would have to be used. However, sometimes a way out of the unpleasant necessity of compounding Latin and Greek roots may be found. Thus in the case of the larynx, for which there is no Latin term, the word *vox* may sometimes be used quite precisely. An artificial larynx like that recently announced by the Bell System, for example, does not truly replace the larynx; rather it replaces the voice. Hence it is an "artivox" and should be so termed.

For naming those devices that are intended as analogs of biological systems rather than as replacements for them, van Bergeijk's proposal seems excellent. For consistency and euphony, the Greek word for the organ simulated should be used as the stem of the name of the simulating device when this is possible. Thus, euphony would be better served if the Perceptron were called an ophthalmomime rather that an oculomime.

To point up the difference between the two types of device and the presently suggested rules for naming them, let us consider the hand. A *chiromime* might be a computer program or a complicated device which imitates and illustrates the functions of the hand; in any case one would expect a considerable degree of sophistication in a device that truly simulates this organ. In contrast, an *artiman* might be only a steel claw serving an unfortunate amputee; with present technology it would have to be fairly simple. Sometime in the future, however, this same amputee might well be able to extend an artiman of friendship, in which case his artiman would also be a chiromime.

PAUL J. BURKE

430 West 24 Street,
New York, New York

30 December 1960, Volume 132, Number 3444

SCIENCE

AMERICAN ASSOCIATION
FOR THE
ADVANCEMENT OF SCIENCE

Board of Directors

CHAUNCEY D. LEAKE, *President*
THOMAS PARK, *President Elect*
PAUL E. KLOPSTEG, *Retiring President*
HARRISON BROWN
H. BENTLEY GLASS
MARGARET MEAD
DON K. PRICE
MINA REES
ALFRED S. ROMER
WILLIAM W. RUBEY
ALAN T. WATERMAN
PAUL A. SCHERER, *Treasurer*
DAEL WOLFLE, *Executive Officer*

Editorial Board

KONRAD B. KRAUSKOPF — H. BURR STEINBACH
EDWIN M. LERNER — WILLIAM L. STRAUS, JR.
PHILIP M. MORSE — EDWARD L. TATUM

Editorial Staff

DAEL WOLFLE, *Executive Officer*
GRAHAM DUSHANE, *Editor*
JOSEPH TURNER, *Assistant Editor*
ROBERT V. ORMES, *Assistant Editor*

BETHSABE ASENJO, CHARLOTTE F. CHAMBERS, SARAH S. DEES, NANCY S. HAMILTON, HOWARD MARGOLIS, ELLEN E. MURPHY, PATRICIA D. PADDOCK, EDGAR C. RICH, BARBARA SUTHERLAND, NANCY TEIMOURIAN, LOIS W. WOODWORTH, CONRAD YUNG-KWAI

EARL J. SCHERAGO, *Advertising Representative*

SCIENCE, which is now combined with THE SCIENTIFIC MONTHLY, is published each Friday by the American Association for the Advancement of Science at National Publishing Company, Washington, D.C. The joint journal is published in the SCIENCE format. SCIENCE is indexed in the *Reader's Guide to Periodical Literature*.

Editorial and personnel-placement correspondence should be addressed to SCIENCE, 1515 Massachusetts Ave., NW, Washington 5, D.C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts or for the opinions expressed by contributors. For detailed suggestions on the preparation of manuscripts and illustrations, see *Science* **125**, 16 (4 Jan. 1957).

Display-advertising correspondence should be addressed to SCIENCE, Room 740, 11 West 42 St., New York 36, N.Y.

Change of address notification should be sent to 1515 Massachusetts Ave., NW, Washington 5, D.C., 4 weeks in advance. If possible, furnish an address label from a recent issue. Give both old and new addresses, including zone numbers, if any.

Annual subscriptions: $8.50; foreign postage, $1.50; Canadian postage, 75¢. Single copies, 35¢. Cable address: Advancesci, Washington.

Copyright 1960 by the American Association for the Advancement of Science.

A Small Note of Cheer

In this space (30 September 1960) we joined others in criticizing the State Department policy that prevented the attendance of government scientists at international meetings attended by scientists from nonrecognized regimes. The Department justified its stand by the argument that nonrecognized countries would claim that the presence of U.S. Government employees at such meetings would constitute *de facto* recognition. It is gratifying to note that this policy has been modified—at least for the specific case of the Fifth International Biochemistry Congress, to be held in Moscow next August.

The new ruling is summarized in a letter that Walter G. Whitman, Science Adviser to the Secretary of State, wrote us on 19 December. The pertinent parts of this letter are as follows:

"You may be interested to know that the State Department has recently indicated to the Department of Health, Education and Welfare that it has no objection to that Department's plans for the participation of its scientists in the Biochemistry Congress. This is in accord with the Department's policy of not hindering the participation of Government employees in international scientific meetings if membership and participation are not based upon political considerations and such attendance is in the national interest.

"The Department does not usually accredit an *official* United States Government Delegation to take part in international conferences at which the attendance of nationals of unrecognized regimes is expected. This does not, however, preclude Government employees from taking part in nongovernmental meetings at government expense without accreditation if the Department of State determines that their participation is in the national interest. Without accreditation, a participant does not represent nor speak for his government."

What the State Department is saying in effect is that scientists do not represent our government officially unless the Department says they do. The device used is accreditation, which makes a distinction between a scientist as a governmental representative and a scientist as a scientist.

The change in policy, although it is a step in the right direction, still leaves some problems about international scientific meetings unsolved. If it is good for government scientists to go abroad to find out what foreign scientists are doing, it is also good for scientists of all political complexions to come to international meetings in the United States. Such meetings facilitate the exchange of information not only for government scientists but for all scientists. The difficulty here lies in the cumbersome handling of visas for foreign nationals, in the refusal on political grounds to grant visas to some scientists from recognized countries, and in the lack of a clear-cut formula for dealing with scientists from nonrecognized countries. Perhaps the Department could rule that foreign scientists who are permitted to attend meetings in the United States are accredited not as officials of their countries but solely as scientists.

Complex though the issue is, the holding of international scientific meetings in the United States is clearly in the national interest. The State Department should find a way to encourage such meetings without jeopardizing the policy of nonrecognition. That it has found such a formula for our own scientists encourages us to hope that it can find one for those of other countries.—G.DuS.

Now, protein analysis in one-tenth the time!

New Bausch & Lomb Serum Protein Meter eliminates complicated chemical procedures . . . frees lab time by cutting nine-tenths off the time previously required . . . reduces possibility of sample contamination.

Just centrifuge the sample. Put it on the Serum Protein Meter. See the result, in protein grams per 100 milliliters, on the direct-reading scale. It's quick, it's accurate . . . and that's all there is to it!

Try it out in your own lab and see for yourself. Just phone your B&L laboratory supply dealer, or mail the coupon.

BAUSCH & LOMB
SINCE 1853

BAUSCH & LOMB INCORPORATED
85612 Bausch Street, Rochester 2, N.Y.

☐ Please send Serum Protein Meter Catalog D-2013.

☐ I'd like an obligation-free demonstration.

Name .....

Professional Address .....

City ..... Zone ..... State .....

30 December 1960, Volume 132, Number 3444 SCIENCE

The Indispensable Tools of Science

Instruments are unifying elements which help self-centered disciplines shed their isolationism.

Paul E. Klopsteg

By century-old custom, a retiring president of the American Association for the Advancement of Science produces a dissertation, to be delivered as his retiring address, on a subject which has occupied an important place in his career.

The 50th anniversary of my membership in the Association is just over the horizon. During these interesting years it has been my good fortune to have been intellectually and physically concerned with the instruments of science—the indispensable tools of science. Gladly do I avail myself of the traditional prerogative to draw together some facts and ideas regarding the role of instruments, whether in the exploration of the unknown or the elucidation of the known.

Throughout the half century of my interest in science I have been impressed with the importance of striving for perfection in transmitting ideas by means of words. Expressing an idea with clarity resembles building accuracy into an instrument. With this in mind, I shall try to tell you what the term *instrument* means to me; but let me first relate an experience apposite to the subject.

An attempt to define the word is identified in my memory with the year 1940. The work of the National Defense Research Committee was getting under way. The committee established numerous divisions, one of which, division D, was under the supervision of the distinguished scientist who was president of this association 25 years ago, the late Karl T. Compton. A section of the division was designated "D-3: Instruments." Its members were long experienced in the means and methods of experiment. During the organizing period we held weekly meetings in Washington to make plans and generate ideas. As we were trying at one meeting, with Compton present, to stake out boundaries for the activities of the section, we put the question to him: "Karl, what is an instrument?" After moments of seeming concentration his reply was: "An instrument is something which doesn't belong in any other section."

The sober implication of this whimsical remark is impressive when one wrestles with the problem of defining the term. One concludes that neither a single nor a simple definition can be easily contrived to meet adequately all the situations in which the word might be used.

Broadly, in science, instruments are the physical means for observation and experimentation directed to securing and utilizing information. Specifically, an instrument may be one of several things:

1) A device in which known physical principles are applied to increase one's perceptivity of natural phenomena, or to render observable otherwise completely elusive phenomena. It is an amplifier for sensory perception.

2) Means for measuring whatever attributes of a physical entity are susceptible of quantitative treatment. It provides numbers which uniquely describe the characteristics observed.

3) Means by which response to a condition may be recorded, or applied to the condition which elicits the response. It makes possible the automatic control of a condition, as in a servomechanism.

4) Means by which recorded information may be treated and processed to make it accessible to evaluation, thereby vastly decreasing the drudgery of manipulating data, or, indeed, making their evaluation feasible.

We shall take for granted what every scientist knows—namely, that observation, measurement, and control, whether in the laboratory or the field, require something more than instruments. The utility of the instrument depends on the availability of auxiliary devices and supplies, the naming of which would be like reading off the index of a catalog of laboratory apparatus and supplies.

To say that instruments with their associated apparatus occupy a place of utmost significance to research, both in advancing basic knowledge and in applying it for human betterment, is to say the obvious. Most research depends profoundly on instruments. Not until an advanced idea, developed by logic into a theory, has been subjected to searching experiment can it attain stability of status. And not until the experiment has been independently repeated and its results confirmed can the theory become assimilated in the body of knowledge. Thus do ideas, forged by logic into theories, and theories, tried and tested with instruments, become science.

It is noteworthy that among the 138 Nobel laureates in physics and chemistry from 1901 through 1960, this high recognition was accorded 112 of them for research in which instruments were dominant. In the 26 instances of theoretical work, the theories became firmly established by experiment and through successful application in further

Dr. Klopsteg, retiring president of the AAAS, is special consultant to the director, National Science Foundation, Washington, D.C. This article is the text of his AAAS presidential address, delivered 28 December before the 127th meeting of the American Association for the Advancement of Science, in New York.

research. But, conversely, theory was also of key significance in the work of the 112 who were distinguished for superb experimental insight. Clearly, there can be no dichotomy between theory and experiment. Without their interaction, there is no research.

The Genesis of Primitive Science

Come, now, if you will, on a speculative excursion into prehistory. Assume the era in which the species *sapiens* emerged from the genus *Homo* to have been contemporaneous with the dawning of reason in man's mind. We may then suppose that this period also marked his becoming first aware, and then observant, of those phenomena which most directly impinged on his existence. This would mark the beginning of retention of some knowledge of nature, and would therefore mark the genesis of primitive science.

The first step must have been taken as he perceived the things and events in his surroundings. These were either commonplace and routine or, on rare occasions, cataclysmic. There were sunshine and clouds, wind and fog. Occasionally he beheld lightning, thunder, tornadoes and hurricanes. Sometimes the sun became darkened in a clear sky, and more often the same thing happened to the moon. When light failed, he could not see. There was heat, and absence of it, and he had little trouble recognizing hot and cold. He heard the rushing of water in streams and on the beach, and he saw the trees sway, accompanied by other sounds of rushing. He saw renewal of life in the bursting bud and sprouting seed. New life in animals and man seemingly began sometime prior to birth. He perceived development and growth, from infancy to maturity, then decline to old age and death, in repetitive cycles. Such things and events were the fabric of the mysteries of his environment and a challenge to his understanding.

Among earliest man, individuals who were observant and curious about the how and why of things developed an image of their circumscribed world which was a composite of these physical and biological bits. The primitive prototype of the modern scholar noted relations among phenomena and saw both similarities and differences in the appearances and structures of plants and animals. When he tried to clarify his picture, with reason not quite measuring up to the task, his desire for understanding had at first to be satisfied with superstitions and with assumptions about mysterious forces having no counterpart in his experience. Parenthetically, and unfortunately, it must be said that this situation still exists among many people in many places, not all of them in underdeveloped countries. Through improved observation and improving reason came the beginning of order, the recognition of some identifiable relations among phenomena. Recognizing and pondering, and reconciling and harmonizing ideas, became matters of consequence to his intellectual development. Man became a philosopher of nature. This he remained through the millenniums during which his ability to observe and think and reason and understand were evolving. But so long as man's intellect was centered on exercises in logic, so long did the infancy of science persist.

Concepts of Time and Distance

It may be surmised that the second feeble step in the gradual emergence of science from earliest infancy was taken when man grasped the concepts of time and distance and tried to express them in terms suited to his needs. Such terms, in his world image, lay near at hand, and, with whatever simple system of counting he had, lent themselves to numerical description. Time was probably first identified with the cycle of waking and sleeping and, for longer intervals, with the lunar cycle. Distances were first expressed in dimensions derived from the body, such as arm span, hand span, length of forearm and foot, and pace. Greater lengths could be described by the stone's throw and the arrow shot and, among nomads, by the day's journey.

If, in truth, early man did find such ways of expressing time and distance, his success probably came not so much from an intellectual quest for definitive knowledge as from efforts to satisfy his need for better communication. Within the implications of this thought is the inference that progress in science depends not solely on measurement. In part, man's earliest efforts to comprehend, in his groping for order and system, probably led to his efforts to confirm his experience with simple experiments. When he had learned to reinforce reason with skill, towards better understanding of his environment, however unsophisticated those first efforts must now seem, he was creating a small base from which to extend his explorations. Measurement, with instruments of special devising, came later.

Emergence from the Past

Suppose we leave him there, and hasten across the millenniums for which present information depends for the most part on conjecture and interpretation to the era of the first inscribed records, from which some facts may be gleaned. Out of later graphic records it is possible to construct pictures of the towering personalities who are associated with the emergence of science from the dim past. Let us fix our attention on a few of the most notable among them (*1*).

Democritus, great thinker and natural philosopher of the 5th century B.C., in proposing the concept of the atom as the smallest, indivisible, invisible, and indestructible particle, laid the foundations of 17th-century atomic theory. The beginning of modern science is often associated with Thales of Miletus, who lived during the century before Democritus. Thales and his successors comprise that remarkable group of men known as the pre-Socratics. Thales, with his idea of the unity of nature; Pythagoras, author of mathematical physics; Leucippus and Democritus, the first to conceive of the atomistic theory of matter—all of them had profound thoughts about nature. With them was born the idea that theory must fit observation—"save the phenomena," as the Greeks had it. Yet no one of them ever thought of an *experiment* designed to relate theory to fact.

Aristotle

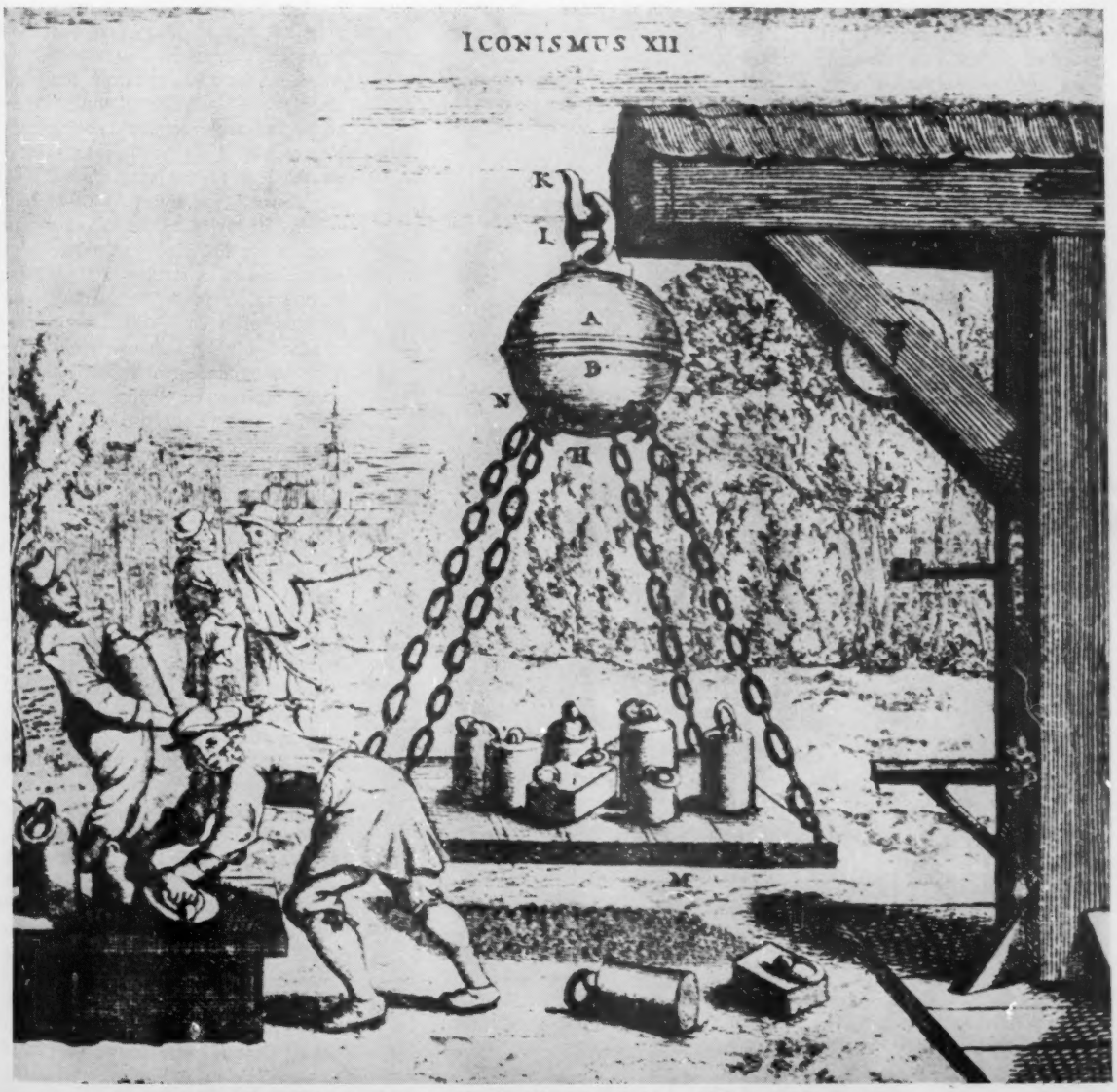
Aristotle came upon the scene about a century after Democritus. His philosophy profoundly influenced the evolution of thought during the next 2000 years. His "reality of ideas," probably derived from Plato's views about reality, his codification of the rules of logic, his scientific habit of mind, and the veneration accorded him as "the master of those who know" by the succeeding generations of scholars resulted, as Dryden has said, in "making his torch

their universal light." When Aristotle's writings appeared in the West, in the 12th century, they were overwhelmingly effective, and for the next three centuries they dominated scientific thought in all but a few areas. Although the Aristotelian view emphasized observation as the crucible for testing theory, its potential in advancing science was impaired by the Greek ignorance of experiment. Hence the working scientist was deprived of the powerful aid of experimental fact. "Experimental fact" is generally established by observation or measurement with instruments.

Galileo

Galileo Galilei stands as our symbol of the new spirit—the "new experimental philosophy," as it was called—which awakened Europe in the 16th and 17th centuries. Galileo adopted the best elements in Greek science—first, logic, and particularly mathematical logic, and second, the insistence that theory must lead to agreement with observation. To this he added the missing ingredient—experimentation: not mere observation of the passing events of nature but deliberate intrusion to shape events to the observer's purposes. He was an accomplished craftsman who personally designed and constructed numerous telescopes, and there is no doubt about his skill in using them. He was the first to scan the heavens with the telescope, to become the discoverer of four of Jupiter's satellites and the phases of Venus. He invented other instruments, among them the forerunner of the thermometer. Shortly before his death Galileo designed a pendulum clock.

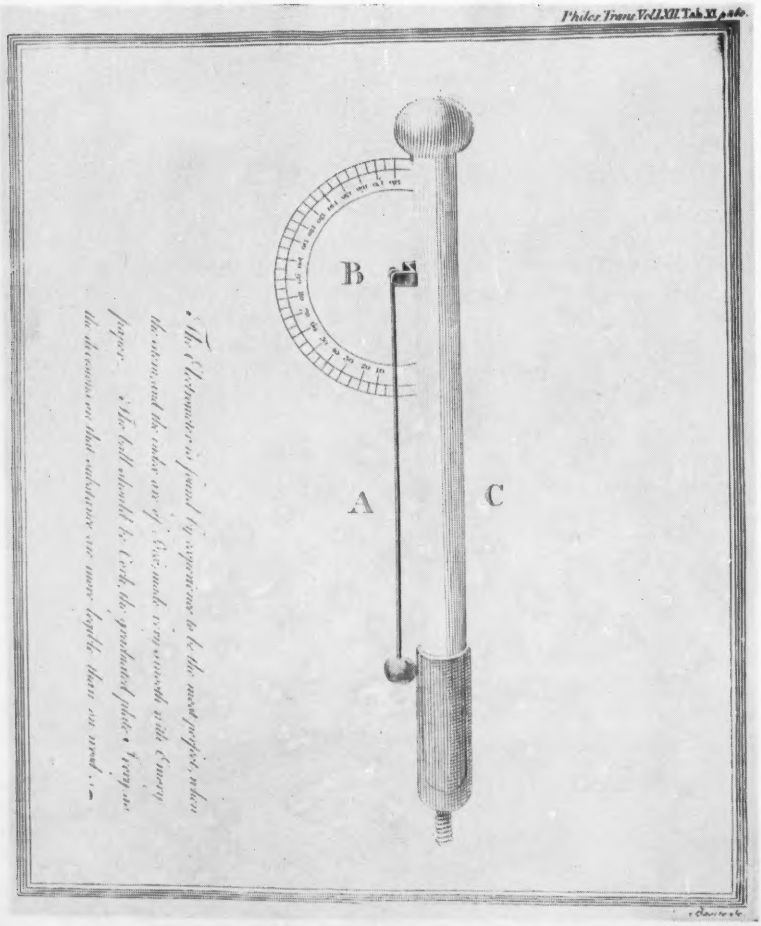
However appealing some of the stories of Galileo's exploits may be,



Guericke's experiments with Magdeburg hemispheres. [Library of Congress]

such as the Leaning Tower story and the swinging-chandelier story, we know them now to be fiction created by his admirers. Others rolled balls down inclined planes and dropped rocks from towers before Galileo. But none of this detracts from the essential character of his resolute adherence to the idea that, in science, experiment is the proof of the pudding. Galileo and his like-thinking contemporaries initiated a "new experimental philosophy"—indeed, a philosophy which recognized the need for new tools, the tools of the experimenter, *instruments*. These soon gave exciting evidence that here were the means, and here was the way, for soundly and solidly building the structure of science. The growing interaction between theory and experiment, like feedback in a regenerative circuit, set off an explosion of ideas and produced a spectacular, unprecedented rise in the level of man's comprehension of nature.

This appraisal of the effect of Galileo's "new experimental philosophy" leads logically to an examination of how the availability of a new instrument may have both immediate and far-reaching effects on the state of knowledge. It would be an absorbing occupation to write a treatise on the consequences of the invention of specific instruments, where many case histories might be fully developed. The Harvard Case Histories in Experimental Science are indicative of possibilities. Within the limits of this article I cannot do more than select and appraise a few examples, having in view their role and the indelible imprints which they left.



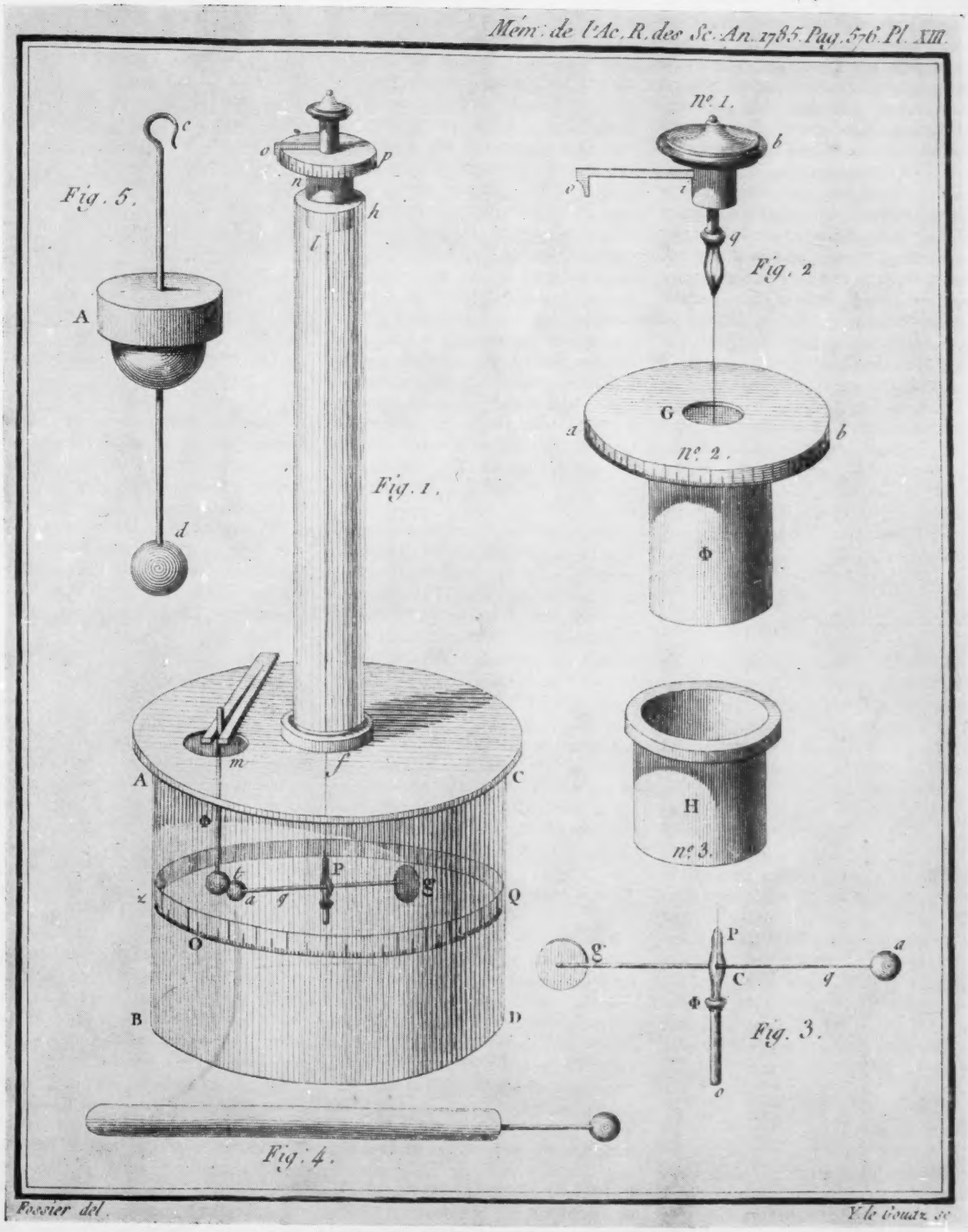
Henly's electrometer. [Burndy Library, Norwalk, Conn.]

Barometer and Air Pump

Prior to the 17th century, nature was "known" to abhor a vacuum. Driven by his desire to see how high a column of mercury would be supported by a vacuum, and thus to learn the extent of nature's abhorrence, Torricelli in 1643 invented the mercury barometer. In modified form, it was also a manometer. He correctly reasoned that the height of the barometer measures the pressure of the earth's "sea of air." Its indications of that pressure and of its variations have made the barometer one of the outstanding inventions among instruments. To test the assertion we need only reflect on how atmospheric pressure affects many physical and biological processes and events, and consider that, without means for measuring pressure, significant studies in the atmospheric sciences could not be made. Nor would it be possible to forecast weather, or to navigate aircraft with any degree of reliability.

Since its invention the barometer has been of inestimable value both in research and in its service to man. From its original form to the mercurial barometer of today—still the primary standard for atmospheric pressure—it has undergone great refinement. Secondary forms, employing an aneroid capsule, are widely used as portable barometers and altimeters, calibrated to the mercury standard. Combined with electronic circuitry, the aneroid made the radiosonde possible. This essential meteorological instrument is comparable in importance to the original invention of Torricelli.

Torricelli of course knew that the space above the mercury in his barometer contained no air. It was a vacuum created by man, subsequently called the "Torricellian" vacuum. A few years later, in 1651, von Guericke developed the first pump to remove air from large enclosed spaces. An improved pump, built by Hooke and used by Boyle, about eight years after von Guericke's, and later models, further improved, deeply stirred the experimenters' imaginations. Astonishing demonstrations were made of the effects of atmospheric pressure and the role of the atmosphere. It was shown to be essential to combustion and respiration. In the absence of air, sound was not transmitted. Objects were found to fall at the same rate in a vacuum, but electric and magnetic forces were not affected.



Coulomb's torsion balance. [Smithsonian Institution]

In its later versions the air pump made possible the gas-discharge tube, the forerunner of the x-ray tube and the principal means of revealing the nature of electrical phenomena in gases. It was the heart of the researches of J. J. Thompson, Rutherford, and many others in studies of electrons and ions and of radioactivity. Its innumerable descendants among the mechanical, diffusion, and ionic types of pumps are the foundation for segments of modern technology too vast for simple comprehension. Of equal importance is their function in the accelerators of high-energy physics, and in the search for methods to bring about and control nuclear fusion. Only a few decades ago a vacuum of 10^{-6} millimeter of mercury was considered excellent, one of 10^{-8} exceptional, and a report of anything beyond that, either error or prevarication. Today's reports nonchalantly talk about a vacuum of 10^{-10} and beyond, which approaches the conditions of outer space, and no one would doubt them. It is an understatement to say that without the air pump, space science would be under a serious handicap.

Pneumatic Trough

Related to the barometer and air pump, because of its dependence on atmospheric pressure, is the pneumatic trough, invented by Stephen Hales in 1727. It consisted of a narrow-necked glass container, filled with water and inverted, with its mouth immersed in another container or trough, and a gas-conducting tube leading into it. With this simple device, measurements could be made of gas volumes released in chemical reactions. It was essential to the work of Priestley, Gay-Lussac, and Avogadro, out of which came understanding of the physics and chemistry of gases. Priestley, for example, in 1772 substituted mercury for water and discovered the water solubility of gases, and he was using mercury in the trough when he discovered oxygen.

Electroscope

Though some electrical phenomena were discovered many centuries ago, electricity could not be systematically and quantitatively studied before the electroscope appeared. W. Cameron Walker has pointed out how dependent progress in electricity was on the invention and improvement of instruments. His observation is validated by the history of electrostatics, culminating in the discovery of current electricity. Volta invented the voltaic pile with the aid of means for detecting the extremely minute charges produced by the contact of dissimilar metals. Up to the time of Volta, the familiar gold-leaf electroscope was the most sensitive detector of electric charges. Simple as it is, it emerged from nearly a century of improvement, beginning with Hauksbee's use of thin leaf brass as a charge detector. Henly in 1770 made an instrument giving numerical indications, called by him a quadrant electrometer, for ascertaining relative amounts of electricity in a Leyden jar, and for finding the conducting ability of different metals. Volta developed a straw electrometer, which he employed with a condenser in his multiplying electroscope. Bennet's instrument, the last of many before 1779, was the most sensitive and was used by Volta between 1790 and 1800.

The gold-leaf electroscope and its derivatives are still widely, if not universally, used in demonstrations and laboratory experiments in electrostatics. Notably, the electroscope, both with leaf metal and the metallized quartz fiber, became the essential instrument in the work of the Curies and of Rutherford, Geiger, Hahn, Meitner, and others in their pioneer explorations in radioactivity. It is impressive indeed to realize the extent to which the present state of knowledge of nuclear physics is indebted to measurements made possible by the electroscope.

Torsion Balance

The torsion balance, devised by Coulomb and presented by him to the French Academy in 1784, made possible the measurement of the very small forces between minute charges of electricity and between weak magnetic poles. The sensitivity of this instrument, heightened when used as a torsion pendulum, enabled Coulomb to verify the inverse-square law for both electrostatic and magnetic forces of attraction and repulsion. Although Coulomb was not the the first to suggest the inverse-square hypothesis in electricity, he *was* the first to present convincing experimental support for it, thus establishing it as the quantitative law that quite properly bears his name. For the first time this made possible the assignment of numbers to the electrical or magnetic states of objects and the application of mathematical procedures in the study of electricity and magnetism. To quote Roller: "Eighteenth century mathematics had to a very large degree developed along lines applicable to Newtonian mechanics, and with the formulation of electrical science in quantitative terms so analogous to mechanics, electricity became thoroughly amenable to mathematical treatment . . ." The effects on the increase in the understanding of electrical and magnetic phenomena in the 19th century were striking if not spectacular. In the modern Washington vernacular, it was a "breakthrough."

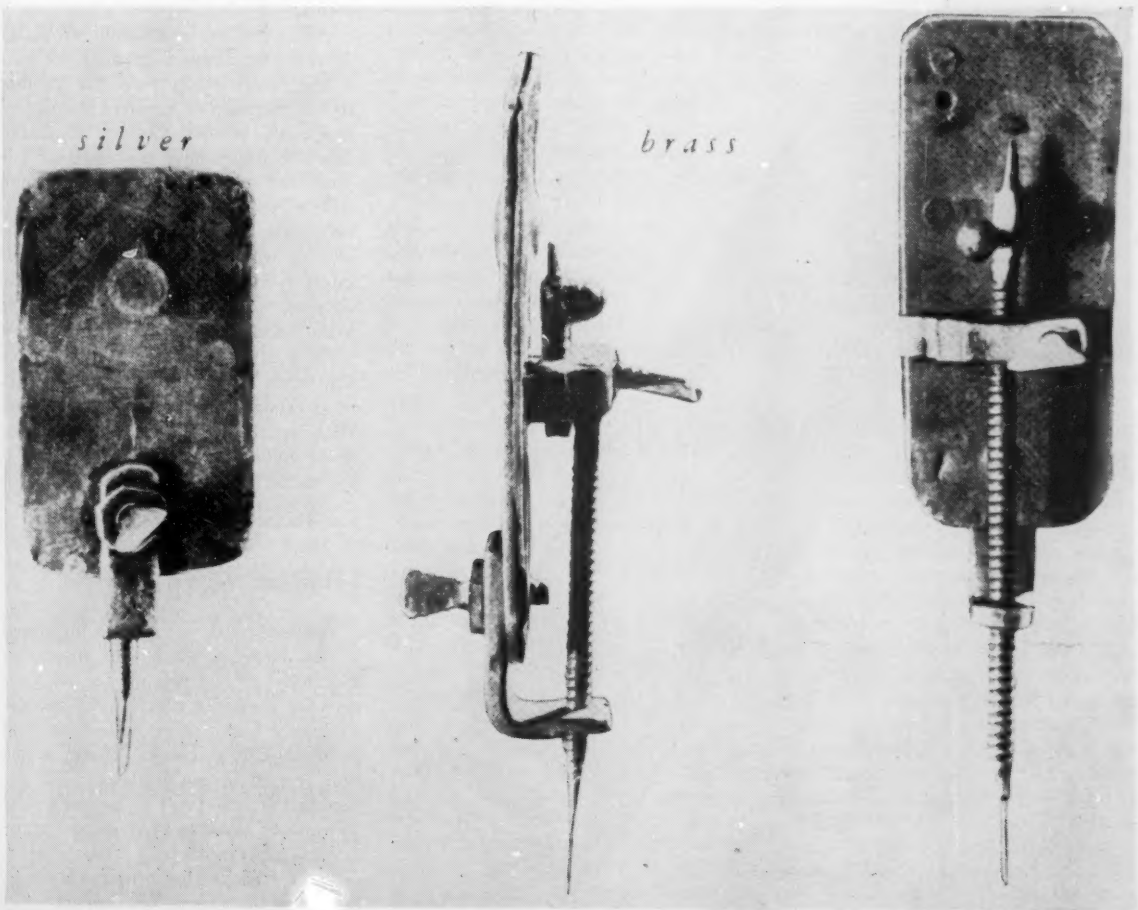
The torsion balance, used as a torsion pendulum by Henry Cavendish, scored another great advance in another application, where far smaller forces had to be measured—namely, the gravitational attraction between known masses in the laboratory. The Cavendish experiment, reported in 1798, proved to be a feat of rare skill and ingenuity, with a relatively simple instrument. In 1687 Newton published his law of universal gravitation, basing it on Kepler's laws of a century earlier. It remained for Cavendish, with an instrument designed independently of Coulomb by the Reverend John Michell of the Royal Society, but never used by him, to measure the force between spheres of lead 2 and 8 inches in diameter, respectively. From this measurement and the known weight of one of the experimental spheres, the gravitational constant and the mass of the earth were obtained, and from its volume and mass, its average density became known. The values found were within 1 or 2 percent of those determined by others a century later.

The Cavendish experiment was significant for several reasons. It accurately measured forces so small that they had escaped observation prior to that time. It provided reliable information from which the masses of bodies in the solar system could be computed. Moreover, the torsion balance of Cavendish, modified in detail and greatly refined, became an important tool in geophysical exploration earlier in this century. With it, gravity gradients could be ascertained and mapped, to provide information about hidden geological structures of special interest in petroleum prospecting.

Microscope

Research with the highly developed microscope of today stands in direct line of descent from notable research done with a simple, strongly converging lens made of a bead of glass. It was an instrument of such almost incredible simplicity that Leeuwenhoek used when in 1675 he discovered protozoa and clearly observed red blood corpuscles, and when in 1681 he discovered bacteria, unicellular organisms much smaller than the protozoa. The compound microscope seems first to have been devised by Janssen, about 1590. It is possible, also, that Galileo converted the optics of a telescope to those of a microscope, about 1610. It seems established that Galileo's fellow-members of the Accademia dei Lincei made the first observations with a compound microscope between 1611 and 1624, but nothing of significance was recorded during this period. The publication of Robert Hooke's *Micrographia* in 1665, however, drew wide attention and produced a great burst of researches in microscopy. Among them were the work of Malpighi, Leeuwenhoek, and Swammerdam. These 17th-century microscopists became qualified to reject the authority of the classical authors, who lacked the microscope, since this new tool opened to them a biological world totally unknown to the ancients. It revealed structures which suggested mechanism, thus supporting a mechanistic view of physiological processes. It directed interest to the lower animals and helped zoology to become an independent science. By the discovery of microorganisms, it vastly expanded the domain of biology. It helped to overthrow the theory of spontaneous generation and established the concept that the cell is the basic unit of any living organism.

All of biology is deeply rooted in ideas which could come only out of the revelations of the microscope. These were limited by the optical imperfections of the early instruments—limitations which were largely removed with the development of lens systems which flattened the image field and corrected for refractive color. These removed spurious patterns from the image and increased the observer's confidence in the reality of what he saw. The latter part of the 19th century brought increasing excellence in the techniques of preparation of materials for microscopic study. Oil-immersion of objectives and condensers increased magnifications. Dark-field illumination and, more recently, phase-contrast techniques, brought within view details not revealed by ordinary transmitted light.



Three microscopes made and used by Antoni van Leeuwenhoek between 1673 and 1723. [National Museum for the History of Science, Leiden; Smithsonian Institution]

Such expansion of the biologist's world is continuing with the further exploitation of optical principles in the techniques of microscopy.

Photosensitive Emulsion

Within the scope of my definition, the light-sensitive emulsion is an instrument, and photography has long been a versatile and effective tool of science, with applications in large number. The use of an astronomical telescope as a camera, permitting long exposures, rendered visible in a developed negative innumerable celestial objects not visible through direct viewing. Star images on a plate permitted accurate measurement of stellar positions and compilation of star atlases. Spectra of stars could be photographed, as could the Fraunhofer lines in the solar spectrum, for convenient astrophysical studies and for reference. For many years advances in astronomy depended largely on the light-sensitive emulsion on glass, the photographic dry plate. What made the photosensitive emulsion so valuable in astronomy renders it equally valuable wherever illumination is too low for direct vision, or where light outside the visible region can affect the emulsion, or where invisible energetic particles produce changes in halide grains which render them developable. Recent progress in raising the speed of black-and-white emulsions and in producing color film of high sensitivity has further increased the value of photography to science. Photomicrography has been of incalculable worth to the biologist, the chemist, the metallurgist, the petrographer—in fact to almost any scientist—by making permanent records of images with magnifications up to 2000 diameters. Beyond this the electron took over from the light waves and became the bridge, by way of the electron microscope and the electron-sensitive emulsion, to magnifications of several tens of thousands of diameters, and resolution of 10 to 20 angstrom units. Without the sensitized emulsion, the electron microscope would have remained a commonplace among instruments.

An important application of photosensitive emulsions is in sequence photography, in which time and position or configuration of transient phenomena are easily related. Only a generation ago one would have dismissed as fantastic the possibility of photographing elusive, evanescent events at a rate exceeding 4 million exposures per second, with good resolution and with intervals measured in millimicroseconds accurate to a fraction of a percent. With special cameras and with new sources of illumination of high intensity when the source is not self-luminous, such high speeds are routine. With special techniques, an increase to 40 million exposures per second is attainable, and the maximum speed is yet to be reached.

Replica of Hans and Zacharias Janssen's compound microscope, copied from the original. [Armed Forces Institute of Pathology, picture No. 53-662-1]

Instruments Not Yet Conceived

Anyone must be greatly impressed if not overwhelmed by the increasing multitude of instruments for all conceivable purposes which have become so highly essential to both basic and technological research. There seems little left to invent or design. Yet the fact that it is difficult to conceive new approaches towards even more sophisticated instruments and systems does not imply that further progress is not to be expected. Indeed, the impact of a new instrument or system for measurement or for control is all the greater

for its having been not easily foreseen.

The day is by no means past when science in amost any field will reach new levels by new methods and techniques in instrumentology. The events of the past several years attest to this: there neither can nor will be a sudden stop to progress in this activity. Without it there would be no space exploration, or, at the other extreme, fruitful research in nuclear physics. To warrant the efforts and costs pertaining to such enormous undertakings, the information must be factual, numerical, and hence specifically descriptive—information obtainable solely by means of instruments. And instruments not yet conceived will yield information not yet within our grasp, or at present imaginable.

The evidence for the indispensability of the instrument to the scientist's endeavors is clear and conclusive. In many cases he devises the instrument to satisfy his own immediate need; perhaps this is the normal pattern. But is this the only way by which new instruments are conceived, invented, and made available for scientific endeavor? Is there prospect of doing better than by the laissez-faire method? By "doing better" I mean doing away with the necessity for the scientist to devote untold hours to struggling with the instrumentation of his research, enabling him to spend those hours more fruitfully and directly on the work within his special competence. Is there possibility, therefore, of working out a division of labor by which the objectives might be reached more expeditiously? Such a possibility exists, I truly believe.

Compartmentalization or Joint Attack

There is no novelty in saying that among the most productive fields of research are those where different sciences converge and overlap. There are such areas in which the problems challenge the interests and the joint effort of scientists from various disciplines. If the challenge is sufficiently compelling, it can draw together special knowledge and ability from different fields and unite them in an attack which any one scientist would not undertake by himself because of his lack of what others can supply. With their resources merged, the undertaking proves manageable. In such a team, one of the members would probably be a physicist or electrical engineer especially conversant with measurement and the associated experimental procedures. Such team research, notwithstanding its successful outcome when tried, is rare. If it is indeed fruitful, why are there not more examples of such accomplishment through cooperation?

The reasons are not difficult to discover. One lies in the tendency for departments in universities, and their faculty members, to isolate themselves in cozy self-sufficiency. The isolation, in the pattern of academic tradition and custom among scholars, raises high intellectual barriers among them. "Compartmentalized" is a descriptive word which has been aptly used. Another reason, and possibly a more fundamental one, derives from the scientist's compulsion to establish a record of achievement through written and oral publication. Unless he sees himself in a clearly defined, specialized field, he may have difficulty finding a publication that will accept his contributions, or a society before which he may give accounts of his works. If he cannot readily let the world perceive his professional qualities, his advancement in prestige and income is jeopardized.

Happily, small breaches are appearing in the walls of the compartments, and movements are developing through which good research will become known and recognized, whatever the content. Biophysics, for example, has come of age in the establishment of a national society and a journal, thereby giving biologists and physicists a two-way channel of communication. The trends in research, moreover, are towards team research on large projects and operations financed by the government, where the potential contributions from various sciences are needed. Members of teams thus engaged are drawn out of various compartments. With increasing recognition that their services are essential and consequently in growing demand, obstacles to individual advancement become less formidable.

Exploration of the feasibility of developing methods for such a joint attack on large problems, where instruments play a primary part, resulted a few years ago in *Publication No. 472* of the National Academy of Sciences–National Research Council. This is a report of the Biology Council entitled, "Instrumentation in Bio-Medical Research." In its hard-core approach to the life sciences through joint effort, it has given impetus to the trend toward abandonment of isolationism among biologists, medical research specialists, physicists, physical chemists, electrical engineers, and others and has indicated ways of bringing about the desirable distribution of effort. The report analyzes how such unified effort may materially strengthen the effectiveness of research in the biological and medical sciences. Answers are sought to such questions as: What can be done to advance the science of instrumentology and the art of instrumentation for greater service in fields where instruments might, in the past, have been more effectively used?

The general answers suggested by the Biology Council apply far more broadly than to biological and medical research alone. They apply wherever the problems are the concern of more than a single science. That some of the suggested solutions are feasible was demonstrated earlier in the work of the NAS–NRC Committee on Artificial Limbs, established in the mid-1940's, at first to study and improve limb prosthetics for amputees in the military services. The benefits of the work are today extending to civilian as well as military areas. It was begun and is continuing under committees in which biology, medicine, psychology, physics, chemistry, and engineering are in close cooperation. Both basic and applied research sponsored through the committees have contributed to the success of the program, in which, through engineering, research findings have been embodied in production designs.

Independently of these moves, the University Corporation for Atmospheric Research, in a comprehensive report of February 1959, proposed a plan with features similar to those in one of the Biology Council's recommendations. The report presents an outline for a National Center for Atmospheric Research, dedicated to "a search for the solutions of broad and fundamental problems of the atmosphere, with emphasis on those requiring extensive interdisciplinary participation." The nucleus of the Center would consist of the most competent research scientists that could be assembled from the various sciences. Its facilities, available to any qualified scientist, would include an instruments laboratory serving the other laboratories, well-equipped shops, and a working library. The Center would assist the scientists

at universities in obtaining the use of large-scale research facilities, including instruments and systems, and would present opportunities for graduate students to engage in thesis research. The University Corporation has energetically moved to establish the Center, and funds have been allocated by the National Science Foundation for the initial steps, including the appointment of a director and his planning and organizing staff.

Other centers, both regional and national, devoted to major research endeavors, are under construction, such as Kitt Peak and Green Bank observatories. Still others will follow, like those designed to carry on the great research programs in oceanography recently proposed. The centers will not be hampered by barriers among sciences and departments, for their mission is to search out answers, not to maintain the straight lacing of straight-laced disciplines! They will provide freedom to communicate, and encouragement to cooperate, throughout their scientific staffs. In all of them, the common factor is dependence on instrumentation.

Instruments, the Unifying Element

Little doubt remains that in our burgeoning activities, research in instrumentology and in instrumentation for research are gaining recognition and respectability. Paradoxical as it may be, the application of research to the furtherance of research is as basic as the research itself. Without it, much research would be vastly more difficult if not impossible. To illustrate: astrophysical studies depend on expert knowledge of the latest in lens design, on image converters, and on maximization of signal-to-noise ratio in microwave receivers; study of the atomic nucleus could not proceed without the application of research to the constant improvement of high-energy accelerators and on their proper design, construction, and management.

The scientist whose research deals with instruments for research is finding his place among his fellows. Since the scientist's reward is, in large part, recognition by scientists, this is important to science, for it will encourage able students to select an interesting and satisfying career. The trend is gratifying. More persons with unusual talent will be needed to assume the planning and execution of the experimental attack as the problems and the instruments for probing them become more involved and complex.

Science faces a bright future. So does man, in his enjoyment of the fruits of science, if he can become and remain a rational being in his relations with his fellow-occupants of this planet. Theory and experiment will continue, as they have in the past, to work hand-in-hand to advance knowledge, and the greatest advances will occur where self-centered and ingrown disciplines shed their isolationism and work cooperatively in exploring dark areas of broad interest. In all such efforts instruments, the indispensable tools of science, are the unifying element; hence they must and will play a vital part.

Note

1. I am greatly indebted for guidance, in my endeavor to appraise the notables in the light of modern historical research, to Dr. Duane H. D. Roller, associate professor of the history of science at the University of Oklahoma, Norman.

Research on Handling Scientific Information

Improvements in communication and information handling contribute to scientific progress.

Helen L. Brownson

Research on new and improved methods of handling scientific information received its initial impetus from an imaginative and stimulating article by Vannevar Bush entitled "As we may think," which appeared in *The Atlantic Monthly* in July 1945. He stated the scientific information problem succinctly:

"There is a growing mountain of research. But there is increased evidence that we are being bogged down today as specialization extends. The investigator is staggered by the findings and conclusions of thousands of other workers—conclusions which he cannot find time to grasp, much less to remember, as they appear. Yet specialization becomes increasingly necessary for progress, and the effort to bridge between disciplines is correspondingly superficial.

"The difficulty seems to be, not so much that we publish unduly in view of the extent and variety of present-day interests, but rather that publication has been extended far beyond our present ability to make real use of the record. The summation of human experience is being expanded at a prodigious rate, and the means we use for threading through the consequent maze to the momentarily important item is the same as was used in the days of square-rigged ships."

Bush predicted a change in this situation "as new and powerful instrumentalities come into use." He indicated tasks that might be performed by existing and potential mechanical aids in adding to the record of accumulated knowledge and in consulting that record. He envisaged a possible future device for individual use, a sort of mechanized private file and library, for which he coined the name "memex." Resembling a desk equipped with slanting translucent screens on which material could be projected for reading and a keyboard with selection buttons and levers, it could store on microfilm a tremendous volume of material—books, periodicals, newspapers, correspond-

The author is program director for documentation research in the Office of Science Information Service, National Science Foundation, Washington, D.C.

ence, longhand notes, and photographs. The stored material would be coded by a technique of "associative indexing," which would tie related items together; and the user would continually build the trails of association while entering new material and consulting stored material.

Fifteen years have passed since this article appeared. We still do not have a "memex" or a technique of associative indexing ready for use. But we do have a whole new field of interdisciplinary research on the handling of scientific information. The phrase "research on the handling of scientific information" is an awkward name to apply to a field, but it seems to me to be the most descriptive and least confusing name that is general enough to cover all the activities that make up this field of research. (The term *documentation research* is often used, but unfortunately *documentation* means different things to different people.) A recent Soviet paper (*1*) indicates that in the Soviet Union, also, this new field has no satisfactory name as yet: "Searches for new ways of storage, dissemination, and processing of scientific and technical information have led to the creation of a scientific discipline (still unnamed), which can be considered a branch of cybernetics."

The lack of an accepted name for a new field of research is perhaps not unusual, particularly when the field is still so young that there is as yet no clear delineation of its scope and no widespread agreement as to research objectives and priorities.

The research that is the subject of this article is concerned primarily with the handling of information expressed in language and other nonquantitative forms, such as photographs and circuit diagrams, as distinguished from quantitative or numerical data. The latter can be quite readily coded, stored, and manipulated by widely understood electronic data processing techniques. But the mechanized handling of the ideas, concepts, and techniques embodied in the texts and illustrations of scientific documents presents difficult problems that have yet to be solved.

It is my purpose in this article to give an informative account of the scope of present activities in the field and brief descriptions of current research projects. It is not feasible in the space of this one article to cover every project, but I shall describe representative projects in each research area. I shall be able to be more informative about the research projects supported by the National Science Foundation, because I am more familiar with them. The foundation, however, has for some years compiled and published a semiannual report on *Current Research and Development in Scientific Documentation*, which contains descriptions of projects and lists of relevant publications and reports. The information contained in the latest number (*2*) of this series serves as the basis of my discussion of the field as a whole.

I shall not attempt to assess the merits of any particular effort or the relative importance of the various areas of research. Any attempt to review the field critically should be based on thorough study of all available publications and reports, a much larger task than any one individual could undertake. In order to make possible such thorough study of work in the field, the National Science Foundation provided funds in 1958 for the establishment at the National Bureau of Standards of a Research Information Center and Advisory Service on Information Processing. Some of the center's operating funds have been provided also by the Council on Library Resources and the Bureau of Standards. The center is assembling all reports and publications in its field of interest and is preparing a number of background and "state-of-the-art" papers on research activities.

Before discussing the various areas of research I shall touch briefly on three other topics in order to provide a certain amount of background information: the organizations supporting and conducting research on the handling of scientific information, the development of special-purpose information-handling equipment, and the extent to which nonconventional information-handling systems are already in use.

Organizations Supporting and Conducting Research in the Field

The National Science Foundation was given a broad directive in its enabling act of 1950 "to foster the interchange of scientific information among scientists in the United States and foreign countries." From the beginning, those responsible for the foundation's scientific information programs believed that one very important means of fostering such interchange would be the encouragement and support of studies of information problems and research directed toward improved methods and techniques for handling scientific information. The National Defense Education Act of 1958 made the responsibility of the foundation in this field more specific. It directed the foundation to establish a Science Information Service to, among other things, "undertake programs to develop new or improved methods, including mechanized systems, for making scientific information available." The foundation has supported studies in the field since 1952, the first year funds for grants were available; but the program, known as the Documentation Research Program, has been expanded considerably since 1956. Insofar as possible it places emphasis on projects of a fundamental or general nature that may produce new insights, knowledge, or techniques applicable to information systems and services.

Like the foundation, the Office of Naval Research and the Air Force Office of Scientific Research support research on information handling in the interests of science generally.

Certain other federal agencies have tremendous internal information-handling problems of their own and therefore have a compelling need to seek better techniques and devices for their own use. The intelligence agencies fall in this category and are making a considerable effort to devise new techniques. In addition to the work within the intelligence agencies, the Intelligence Laboratory of the Rome Air Development Center, an activity of the Air Research and Development Command, supports under contract a good many research and development projects. The U.S. Patent Office also handles a tremendous volume of information and has an extensive research program of its own on the mechanization of patent search procedures. The National Bureau of Standards is collaborating in the research program of the Patent Office and is also conducting independent research on various aspects of mechanized information handling.

Research on mechanical translation is currently supported by the Air Research and Development Command, the National Science Foundation, the Central Intelligence Agency, the Office of Naval Research, the Office of Army Research, and the Army Signal Corps. An Interagency Committee on Mechanical Translation Research has been established by the National Science Foundation to coordinate the administration of these various research programs.

In addition to these federal agencies,

some private organizations provide funds for work in the field. The Council on Library Resources, established in September 1956 with a grant of $5 million from the Ford Foundation, has initiated and supported many studies of library problems, including a number of projects concerned with the development of new information-handling equipment and new indexing techniques. The American Society for Metals for more than three years has financed a mechanized literature-searching project. The Chemical Abstracts Service and the American Institute of Physics have active research programs on information handling and dissemination, supported in large part by the National Science Foundation.

Much of the more fundamental research in the field is being done by a dozen or so universities with the aid of grants or contracts from federal agencies, and their number is gradually but steadily increasing. Private firms and research institutes are also doing a good deal of research in the field, most of it under contract with federal agencies or the Council on Library Resources.

Organizations abroad that are actively conducting research include the following: several governmental organizations, a society of librarians and information specialists, and a private language research group in England; a university laboratory of social psychology and a center for nuclear research in France; Euratom, an international organization with headquarters in Brussels, which has an internal research program in this field and contracts for additional work with organizations in several European countries; the Patent Office of the Netherlands; a library research group in India; and a number of research institutes in the Soviet Union that are concerned broadly with the applications of electronic machines and with the field of linguistics.

Development of Special-Purpose Information-Handling Equipment

Although standard punched-card equipment and general-purpose computers are used in most mechanized information systems and in most of the research in this field involving the use of machines, a number of devices designed especially to handle linguistic and graphic information have been and are being developed. The following are examples.

Perhaps the earliest development was the Rapid Selector (*3*), conceived by Vannevar Bush before World War II. The first model was built by the Engineering Research Associates, of St. Paul, Minnesota. It scans very rapidly a large reel of microfilm containing textual material on one side of each frame and coded information on the other and selects and reproduces the frames for which the codes meet prescribed specifications. The latest version of the Rapid Selector embodies some modifications built into it in recent years at the National Bureau of Standards and is in use in the Bureau of Ships of the Department of the Navy.

Minicard equipment (*4*) has been developed for the Air Force by the Eastman Kodak Company, and three sets of the equipment are now in use either operationally or experimentally. A set of Minicard equipment includes a special camera for photographing documents to be entered into the system, a film processor, storage magazines, a Minicard duplicator, a sorter, a selector, a viewer, an enlarger, and so on. The Minicard itself is a discrete piece of microfilm measuring 16 by 32 millimeters and containing up to 12 pages of text and an area for codes.

The AVCO Corporation, with partial support from the Council on Library Resources, has developed a high-density, rapid-access information storage device to provide a means of automatically gaining access to large collections of documentary material. As with the Minicard system a microphotographic medium is used for information storage. A model based on a 100:1 reduction of page size is under construction.

Filmorex equipment, a French development, stores and searches information recorded on "*microfiches*," microfilm cards measuring 35 by 60 millimeters. Each *microfiche* holds up to two pages of text and up to 20 codes or indexing terms. The cards pass through the Filmorex selector at the rate of 700 per minute, and the textual material on the selected cards can be enlarged and reproduced automatically.

Magnacard equipment (*5*), which has been developed for the Air Force by the Magnavox Company, uses individual magnetic cards as the basic storage medium and pneumatic techniques for selective transport of the cards to achieve any desired grouping or rearrangement.

Another development, which has been supported in part by the Navy and the Air Force, is the photoscopic disk and associated equipment at the IBM Research Center. It is a large-capacity, random-access device that manipulates coded, photographically recorded information. It was designed to be particularly well suited to the handling of natural languages for such purposes as automatic translation and information storage and retrieval.

The Rabinow Engineering Company is also developing a large-capacity, rapid-access device in which information is stored as small holes etched in metal plates. It is believed to be suitable for use as an automatic dictionary in translation or retrieval systems.

The Laboratory for Electro-Modeling in Moscow has developed, for use in information-handling systems, a storage device that uses sheets of paper on which small capacitors have been preprinted (*6*). Information is stored by punches in the sheets, each punch disconnecting a capacitor. The sheets are electrically interconnected to permit very rapid electronic searching of the stored information.

Quite a number of organizations are developing character-recognition devices that will automatically "read" alphabetical and numerical characters. Reading machines that are versatile enough to recognize different styles and sizes of printed type will be needed to provide the "input" to translation and information retrieval systems.

A principal point to be made in discussing equipment is that we do not yet have procedures for handling information that enable us to use existing equipment to best advantage. When effective procedures have been developed and tested, still other special-purpose devices may be needed. But it would appear that the state of our computer technology is sufficiently advanced that any such device can be readily built if the engineers can be told in very precise terms just what it must be able to do.

Current Use of Nonconventional Information-Handling Systems

The National Science Foundation issues a series of reports on *Nonconventional Technical Information Systems in Current Use* as a service to individuals and organizations interested in scientific-information handling. The latest number in this series, and its supplement (*7*), describe in general terms 52 systems that employ either nonconventional indexing techniques or automatic equipment, or both. The reports also list available publications describing the

systems in more detail. These 52 systems are by no means all the systems of this kind in existence, but they exemplify the various types of systems now in use. Brief descriptions of a few of the larger partially mechanized systems will illustrate the success with which new techniques and machines are being applied in systems now in operation and giving service to users.

The Merck Sharp and Dohme Research Laboratories use an IBM 101 Electronic Statistical Machine and punched cards for storing and searching index entries for publications in the fields of pharmaceutical chemistry, biochemistry, microbiology, and so on. The system was initiated in 1950 and covers about 60,000 documents. A panel arrangement, on which code numbers are indicated with switches, facilitates the setting up of searches for code patterns. This panel was developed at the Merck Laboratories for use with the 101.

The Socony Mobil Oil Company and Smith, Kline and French Laboratories both have punched card systems employing also the IBM 101. Each system covers upwards of 100,000 documents. The Socony system, in operation since 1952, covers journal articles and patents on petroleum chemistry. The SKF system, in use since 1953, covers the chemical, biological, and clinical data in published papers and internal reports.

The General Electric Company in Cincinnati has combined a system of key word indexing for about 50,000 documents on flight propulsion and related subjects with a program for searching the coded information on an IBM 704 computer. A machine search can be made to produce either a list of the accession numbers of documents identified as being relevant to the search prescription or printed citations and short abstracts of the documents identified.

The Office of Basic Instrumentation, National Bureau of Standards, has designed a "peek-a-boo" system, which covers some 30,000 papers and reports on instrumentation and is probably the largest operating system of its type. It makes use of 5- by 8-inch cards, one for each indexing term in the system, and punching and viewing devices. Each card has provision for 18,000 holes, and each hole punched on a term card identifies by its location a document that has been indexed by that term. To search for documents relevant to combinations of terms, the appropriate term cards are stacked in front of a light source, and the holes in alignment that permit the light to shine through all of the cards identify the documents relevant to the selected terms. Since the capacity of a card is 18,000 holes, another set of cards must be started after 18,000 documents have been indexed.

Among the foreign systems of particular interest is that of the documentation center of the Centre National de Recherche Scientifique, in Paris. Employing Filmorex equipment, the system has been in experimental operation for four years and stores abstracts and codes for some 200,000 papers on the biological effects of chemical compounds.

Of the 52 systems described in the foundation reports, 34 deal primarily with chemical or biochemical information and 35 are operating within industrial organizations. Whether these proportions would hold true for all existing nonconventional systems is not known, but at least they suggest that the incentive for devising information-handling systems and for attempting to use machines and new techniques for this purpose is greater in industry than elsewhere. Similarly, it might be inferred either that chemical information is more readily coded for mechanized handling than other information or that chemists and chemical literature specialists are to some extent more interested than specialists in other disciplines in trying out new information techniques. Perhaps both inferences are correct.

Even the larger systems that have been described are small in comparison with the task of placing indexes to the content of all scientific literature under some sort of mechanized control. It is not at all clear that procedures that work satisfactorily for limited collections of information in relatively homogeneous fields could be adapted to handle very large volumes of material cutting across a number of scientific disciplines.

A recent report of the Senate Committee on Government Operations (*8*) contained a brief description in general terms of a very large punched card system for intelligence information—the "Intellofax" system of the Central Intelligence Agency. The system was instituted in 1947 and has undergone some modifications since then. It now comprises over 40 million punched cards; those prepared in recent years bear both coded information and microfilms of documents mounted in apertures in the cards. Quite understandably, the agency has not made available detailed information about the system. For intelligence purposes, however, it may not be necessary to index or classify the subject matter of scientific and technical documents to anything like the the depth that would be required for a system designed to make literature searches for scientists.

One last observation about the existing partially mechanized systems is that most of them appear to be based on some form of "coordinate" indexing, which makes use of individual indexing terms or short compound terms that can be combined in a variety of ways in the process of searching. Conventional indexing or subject-heading systems include phrases as index entries whenever several terms are required to describe a concept. The indexing terms of a coordinate system may be called key words, descriptors, Uniterms, or simply terms. By now, a good deal of experience has been gained with systems of this type, some of which incorporate techniques for handling various types of relationships among terms. The National Science Foundation, therefore, has contracted with Documentation, Incorporated, of Washington, D.C., for a state-of-the-art study of all aspects of coordinate indexing, including operating experience, theoretical work, and experimentation. The report of this study should be available early in 1961.

Current Research Activities

In spite of rapid and continuing progress in computer technology and programming techniques, continuing development of special-purpose devices for the handling of linguistic and graphic data, and accumulating experience with mechanized techniques in searching limited collections of information, the essential problem of applying machines to the handling of scientific information on a large scale has yet to be solved. This unsolved problem has to do with means of analyzing the subject content, meaning, and relevance of documents for mechanized handling. Research directed toward this end is making progress but is still in its infancy.

Only a few short years ago, most people in the field were thinking in terms of attempting to mechanize only the more routine or clerical aspects of information handling, with reliance on human judgment for the analysis and indexing or classification of the subject content of documents. All of the present operating systems that employ automatic searching techniques are of this type. Much of the current research work

is directed toward the development of improved indexing or classification systems to be used by human analysts in combination with automatic techniques for coding, storing, and searching the index data and printing out the results of a search. Continued work in this area is important because improved systems of this type will undoubtedly be useful for many purposes.

Within the past five years, however, more and more persons have become interested in exploring how far it is possible to go in devising ways of using machines to process and analyze automatically the actual language of documents for a variety of purposes—translation, abstracting, indexing, selective dissemination, and storage and retrieval. Some of the current research efforts on the processing of information for dissemination and retrieval and all of the mechanical translation efforts are in this area.

The following descriptions of research activities are grouped under several headings: background studies of the communication practices and information needs of scientists; research on partially mechanized information retrieval systems, with mechanization applied to the more routine processes subsequent to document analysis; research on the automatic analysis of texts; evaluation and comparison of information-handling systems and procedures; and studies in other areas.

Communication Practices and Information Needs of Scientists

Although most of the research described in this article is directed toward the development of faster and more reliable techniques for handling scientific information, it goes without saying that the information needs of the scientific community should determine the character of new information services and techniques. Although there is a good deal of intuitive and subjective knowledge about the various ways in which scientists communicate the results of their own work to others and learn about the work of others, there is very little precise, objective knowledge of the inadequacies in the present flow of scientific information and of the cost to scientists and to society of those inadequacies. A deeper understanding of the role and the mechanics of communication within the sciences and of the information problems and needs of scientists would be of assistance to scientific societies and all other organizations involved in planning and maintaining publication programs and scientific and technical information services. Such understanding is also needed for the design of information-handling systems and procedures that will provide the sort of help scientists can use to best advantage.

In an excellent discussion of the problem of "technical communication in psychology" (*9*), the Board of Scientific Affairs of the American Psychological Association presented the thinking of a group of psychologists on the need for work in this area of communication practices and information needs:

"BSA considers the problem of efficient and effective communication of scientific information to be perhaps the most critical problem faced by scientific psychology today. . . . The techniques of scientific communication now employed by psychologists have evolved from past experiences, conditions, and needs, without much self-conscious analysis or deliberate planning.

"The interdependence of the functions of different media of communication suggests that psychologists should self-consciously design a communication system in which the inherent capabilities and limitations of different media are matched with the specific needs or functions to be served. Only by the analysis of such a total system will it be possible to specify the required media, their principal functions, and the criteria in terms of which they should be evaluated.

". . . traditional roles of our communication media need to be reexamined in the light of present and anticipated information loads and needs. Further, these needs should be those of the user of the information rather than those of the originator of the information."

During the past 10 to 15 years, some 30 or more studies and surveys have been made of the use by scientists of scientific publications and reference tools and of their views on information problems and services. Most of these studies have been made by means of questionnaires or interviews, in which scientists were asked to recall or to estimate their use of publications and services. A few investigators have used other techniques for gathering data, and some have attempted to delve deeper into the communication problem and to identify actual situations where research suffered because certain existing knowledge was not available, and thus to throw some light on specific failures of our present communication system. By and large, however, the studies thus far have been concerned with what scientists do in the present situation, which is admittedly far from perfect. They should be regarded as merely a first step toward better understanding of the information problem, to be followed by experimentation with courses of action likely to lead to improvements in the situation.

Studies in this area prior to the summer of 1959 were analyzed and compared in a *Review of Studies in the Flow of Information Among Scientists*, prepared for the National Science Foundation by the Bureau of Applied Social Research, Columbia University, and issued in January 1960. This review contains a discussion of completed research and a synthesis of the findings of the various studies wherever the data are at all comparable. The many obstacles to comparison included the diversity of populations studied, differences in the units of observation or recording, differences in classification of communication media and channels, and paucity of analyses in depth and of interpretations of the collected data. Some of the studies were designed for the purpose of guiding the activities of a single establishment and were useful for that purpose but added little to the knowledge needed for decisions on a more general level. Techniques of data-gathering have included the analysis of library withdrawal records (with or without special questionnaires attached); study of records of inquiries at information centers; use of questionnaires, interviews, and diaries; and observations during specified time intervals.

The choice of technique, however, is believed to be secondary in importance to careful delineation of the area of inquiry and of the units of observation. The review states the belief that the time has come to devise new research strategies and suggests some neglected approaches that seem both feasible and promising, such as studies focusing attention on the functions of the scientific communication system and the ways in which each is being met and studies designed to determine how individual units of information percolate through the scientific community.

Among the studies in progress at present, two are being conducted in in-

dividual industrial laboratories. A group at the Bell Telephone Laboratories is analyzing the responses to questionnaires sent to their 4700 technical and administrative personnel to obtain data on the use of the library and of information; a paper on the principal results and implications of the study will be published. The Technical Information Division of the Esso Research and Engineering Company is analyzing some 2000 requests for technical information, covering both current reference use of materials and retrospective searches of published literature and internal reports. It is hoped that the study will help to determine the types of indexes most useful for answering the questions put to the Division.

The Institute for Advancement of Medical Communication is conducting two very similar studies of the fate of papers given orally at scientific meetings. The purpose is to discover what proportion of them are eventually published, the factors determining whether or not a given paper is published, and the time lag between oral presentation and publication.

The American Institute of Physics is experimenting with various forms of printed indexes to see how they are received by physicists and how useful they prove to be in practice, and is studying several aspects of current publication practices in physics.

The Operations Research Group at the Case Institute of Technology is obtaining data on the use of published scientific literature by chemists and physicists. A technique has been devised whereby the participating scientists, by using a random alarm device, make notes at random intervals on what they are reading, if they are in fact reading when the alarm sounds. This study is a continuation of an earlier operations research study of the scientific activity of chemists (*10*), in which both observations by others and self-observations away from the place of work were used. The data collected on a large representative sample of chemists indicated that the average chemist working in industry seems to spend more time in scientific communication (reading, writing, listening, and talking about scientific matters) than in all the rest of his activities concerned directly with science. Of a total of 32.4 hours per week (both during and after working hours) devoted to scientific activities, 16.5 hours were spent in scientific communication, as compared with 10.4 hours in working with equipment, 3 hours in data treatment, and 2.5 hours in thinking and planning. Comparable figures are not available for university chemists, because the "after hours" portion of the study covered only industrial chemists. Although the 25,000 observations made during the first study resulted in a clear picture of the prominent role of communication in the activities of chemists, there were relatively few (some 900) observations of reading acts, not enough from which to draw conclusions. Consequently the present phase of the study is aimed at gathering more data on the use of publications.

Another study of the use of publications is being made by the University of Chicago Library to determine whether the present or potential value of publications can be established on the basis of frequency of use, and whether criteria that will predict their future use or obsolescence can be discovered. Browsing patterns, as well as circulation use, for both journals and monographs are being examined in several subject areas. The prediction of obsolescence functions will be tested against expert judgments, and the data collected at the University of Chicago Library will be compared with check samples taken at other research libraries.

The question of measurement of the value of recorded scientific information is to be explored in a new study just getting under way at the Case Institute of Technology. It will encompass a survey of the various measures of the value of information and of scientific productivity that have been used, a controlled evaluation to determine their usefulness and limitations, and an exploration of the feasibility of developing more reliable measures of value. The value or significance, and also the rate of obsolescence, of scientific papers and of the information contained in them are factors which must be taken into account, if possible, in designing improved means of scientific communication and mechanized searching systems.

It will be apparent from this brief summary that the current studies of communication practices and information needs of scientists are concerned with pieces of the problem. Plans have been discussed for a thorough "systems analysis" of communication within certain scientific disciplines, but no such study has yet materialized. Perhaps the next step in this area of research will be one or more broad studies covering all aspects of communication within a discipline with the goal of working toward the design of an improved total communication system for that discipline.

Partially Mechanized Information Retrieval Systems

Some of the current research projects on information retrieval systems are concerned with the development of improved procedures for the analysis, indexing, or classification of the subject content of documents for use by human analysts and with the development of mechanized procedures for the subsequent, more routine, steps, such as coding the index entries for machine storage, matching search prescriptions against the stored data, and printing the results of a search.

The Chemical Abstracts Service has a broad research program directed toward the mechanization of information services in chemistry (*11*). Using existing equipment and techniques, they are experimenting with ways of coding data on the structure and properties of chemical compounds for mechanized storage and retrieval and for automatic preparation of data compilations. An important part of the broad program consists of research on the semantic content of chemical literature in order to discover whether basic patterns of the terms and phrases used can be identified and to determine how best to handle, in a mechanized system, the concepts expressed in language. The research tasks include the preparation of concept dictionaries and their experimental use in the processing of abstracts and mechanized searches.

The Cambridge Language Research Unit, Cambridge, England, is attempting to devise a mechanizable information retrieval system based on a thesaurus-like lattice structure of terms taken from the documents indexed. The system is being applied experimentally to the Unit's collection of reprints. Since the number of terms tends to increase rapidly as documents are added to the collection, attention now is being devoted to research on methods of combining terms on the basis of their tendency to occur together in documents. The present work is largely theoretical, being concerned with the development of a general method of grouping, the careful choice of defining criteria for

groups, and the formulation of mechanizable procedures for finding the groups in a given set of terms.

The Ramo-Wooldridge Division of Thompson Ramo Wooldridge Inc. is investigating the utility of assigning weighting factors to index tags, indicating in an intuitive way the degree of relevance of a tag to the document being indexed (*12*). Through the use of such "probabilistic indexing," it may be possible to improve retrieval efficiency and effectiveness by listing documents identified in a search in order of degree of relevance to the question. The degree of relevance is determined by a computational procedure in which the weighting factors assigned both to index tags and to components of a search question are used.

Soviet efforts in this area appear to be concentrated primarily in the field of chemistry (*13*). The goal is to develop, for use with machines, a "machine language" for the fundamental forms of chemical information. The Electro-Modeling Laboratory in Moscow has developed a system of unambiguous linear notations for structural formulas and their components suitable for mechanized handling, and has also developed symbols for chemical reactions which can be combined with the linear notations. This special chemical information language is being extended so that it can be used to express information on the mechanism of chemical reactions, the technical conditions of their realization, and the properties and behavior of physicochemical systems so that eventually the language can handle all knowledge in the fields of chemical science and engineering. It is hoped that in time chemists will be used only to select information from the literature for incorporation in the mechanized information system. Means are being devised for automatically converting structural formulas, various types of names of compounds, and other information into the notations and codes of the machine language. Eventually, with automatic reading devices, it is expected that the coding of structural formulas can be done entirely without human intervention.

The two remaining programs described in this section are placed last because, although their more immediate results will be applicable to partially mechanized systems in which the analysis is performed by human beings, some aspects of the work are relevant to mechanization of analysis and thus relate to the following section as well.

The United States Patent Office has a broad program of research directed toward the design, construction, and experimental use of mechanized search systems. Techniques are already in use for mechanized searching of the steroid patents, and similar work is well under way in the additional fields of the polymer art, chemical processes, organic phosphates, and electrical arts. The several concurrent projects include studies of ways of characterizing and coding the essential elements and relationships that make up the patents in the fields mentioned; studies of various search techniques, with experimentation primarily in the field of chemistry; and studies of techniques for file preparation and organization. The specific projects within the Patent Office program that are directed toward the ultimate goal of automatic analysis of complete texts for mechanized searching are concerned with the linguistic interrelationships that occur in patents and related technical literature; the creation of a regularized unambiguous language, termed "ruly English"; and methods for converting natural language to a standardized form.

A research group at the Itek Corporation is endeavoring to systematize the operations of information searching systems (*14*). The ultimate goal is the mechanization of such operations wherever feasible, but some of the systematized procedures being deveolped may first be applied by human analysts. The operations under study include the selection of significant information items in a scientific text as index data, their conversion from natural language into a normalized language, the interpretation of search questions and their conversion into the same normalized language, and the planning and programming of searches. A method of representing natural-language expressions in normalized form is being developed. The "normal" grammar, which is based on concepts derived from logic, is used as a schema in the semantic organization of linguistic data, in the normalized representation of complex topics, and in the selection of index data. The project also includes the development and testing of tools, such as a dictionary of terms and operational rules governing the conversion of natural-language expressions into their normalized equivalents, and a thesaurus-type device that records and displays the semantic relationships among words and expressions.

Automatic Analysis of Texts

Current reseach on the automatic analysis of complete texts of scientific documents includes experimentation with indexing and abstracting techniques based on word-frequency statistics and tests of procedures for direct searching of entire documents for specified words and phrases (*15*). It also includes exploration of the feasibility of more elaborate techniques, beginning with automatic syntactic analysis of the sentences of the text.

A research group at the International Business Machines Corporation is experimenting with the use of statistical techniques to prepare abstracts and indexes automatically (*16*). A machine program is used to scan the entire text of a document and to identify significant words and their positional relationship to each other within sentences. From these data, a significance value is assigned to each sentence, and those sentences with the highest values are printed out as an "auto-abstract." For automatic indexing and encoding purposes, similar statistical procedures are used to establish lists and patterns of high-frequency words, and of pairs of words occurring together within sentences. The words may then be looked up in a special "thesaurus" that is stored in the machine and assigned code numbers designating the appropriate notional families. Variations on these techniques are being tried experimentally; these include an automatic system for the selective dissemination of information (*17*), based on comparison of the patterns of key words resulting from analysis of documents with the words characterizing the interests of scientists participating in the experimental program.

The Ramo-Wooldridge Division of Thompson Ramo Wooldridge Inc. is experimenting with automatic text searching with the ultimate goal of fully automatic indexing and word correlation. A recent set of experiments measured the effectiveness with which information responsive to specific questions can be recognized through machine search of the full text of documents. The experiments have been carried out within the framework of a "model" information system, consisting of a small collection of physics articles, a list of *ad hoc* questions, and a matrix of numbers representing the estimated degree of relevance of each article to each question, based on careful application of expert

human judgment. The questions were transformed into instructions to search for specified words and phrases within the texts. The texts of the model library, recorded digitally on magnetic tape, were then searched by a general-purpose computer. The responding documents were compared with those determined to be responsive through examination by subject specialists of the entire collection of articles. They were compared also with those identified by searching a conventional subject-heading index of the model library. The investigator has reported that, on the whole, retrieval effectiveness was rather poor, yet machine search of the texts produced significantly better results than human searching of the subject-heading index. Such exploration of the effectiveness of text-searching techniques is considered to be a prerequisite to the design of effective automatic indexing procedures, in which abbreviated representations of documents must be prepared by machine. The work is being extended to include a study of the feasibility of preparing abstracts automatically.

The Institute for Cooperative Research at the University of Pennsylvania is studying possibilities for mechanizing indexing and is attempting to devise sampling techniques to investigate the effectiveness of machine instructions for assigning indexing terms to documents.

A group of linguists, logicians, mathematicians, philosophers, and electronic engineers, working within the Department of Linguistics of the University of Pennsylvania, has for several years been engaged in an intensive program of research on the mechanization of syntactic analysis of English sentences (*18*). In their view, the automatic processing of the texts of documents for abstracting, indexing, and retrieval should begin with automatic phrase-structure analysis, or parsing, of the sentences of the text. A computer program for this type of analysis is being prepared. The second major step in the processing of documents, on which this group is working, will be a computer program for "transformational analysis"—converting sentences into simpler, more uniform "kernel" constructions (for example, passive constructions will be converted into simple, declarative statements). The planned third step will consist of procedures for the identification of significant words or "kernels" for storage in a retrieval system or for use in abstracts and indexes.

An investigator at Massachusetts Institute of Technology is studying the possibilities of using natural language for storage and retrieval in a mechanized literature-searching system. The work is based on the belief that it should be possible, by an appropriate research effort, to deduce the rules of natural language in explicit form so that machines can be explicitly instructed on the use of the languages. A step-by-step approach is used, each step bringing the artificial language, or "dialect," closer to English and incorporating within the language as many features of English as are thoroughly understood at the time.

The work on automatic syntactic analysis, or parsing of English sentences, that is being done in connection with information retrieval systems is closely related to much of the current research in the field of mechanical translation. Eleven research groups are active in this field in the United States, three in Great Britain, and at least six or seven in the Soviet Union; work is also under way, or is at least beginning, in Italy, France, Sweden, East Germany, Czechoslovakia, Yugoslavia, Japan, and Communist China. As one would expect, the groups in the United States and Britain are developing syntactic analysis techniques for foreign languages—primarily Russian, German, and French, with work just beginning on Chinese. The results of some of this work are beginning to be applied experimentally to English as well; for example, the "predictive analysis" technique, developed at the National Bureau of Standards and adopted also by the group at Harvard, is being tried on English at Harvard. Research in mechanical translation also includes studies of the semantic organization of languages. This work also, although oriented primarily toward translation procedures, may prove to be relevant to other information-handling procedures as well. In fact, some of the research groups and supporting agencies are interested in mechanical translation primarily as one aspect of the larger field of automatic processing of natural language for a variety of purposes. It is interesting to note that this view has also been expressed by a Soviet researcher (*19*).

"Today machine translation is regarded only as the first stage toward solving a more general and more important problem: by most fully using electronic machines as auxiliary tools of human thinking, to make the machine capable of performing the widest possible operations with texts written in different languages, to enable it not only to translate but also to edit, make abstracts, furnish bibliographical and other references, etc. All these operations boil down to extracting from the text required information and to recording that information in some other form."

Evaluation and Comparison of Information-Handling Systems

We are just at the beginning of serious efforts to evaluate and compare under controlled conditions the effectiveness and efficiency of information-handling systems and procedures. The Ramo-Wooldridge experiments with automatic text-searching procedures, described in the preceding section, included a carefully controlled comparison of their results with results obtained by human searching of a conventional subject-heading index. Several other current projects are concerned with evaluation and comparison of procedures and systems.

A project at the Cranfield Aeronautical College of England, administered by the Association of Special Libraries and Information Bureaux, involves tests of the comparative efficiency of four indexing and classification systems, which have all been applied under controlled conditions to a sample of 18,000 documents in the field of aeronautics (*20*). The systems are the Universal Decimal Classification, widely used in European libraries and publications; a "faceted" classification (*21*) devised for this project by members of the Classification Research Group of England; a conventional subject-heading system; and a system of coordinate indexing. The test searches are now in progress, and some preliminary results may be available by the end of 1960, and final results by the end of 1961. It is hoped that the results of this project will provide convincing evidence of the relative efficiencies of the systems for various purposes and will add to our knowledge of techniques for evaluating systems. It may also provide information that will be useful in the design of indexing and classification systems.

Herner and Company has developed an experimental classification and coding system for the field of atomic energy, suitable for use in either manual or mechanized information retrieval systems. The next phase of this project is

a comparison of the system's retrieval effectiveness with that of a subject-heading system and a coordinate indexing system now in use in the libraries of the Atomic Energy Commission.

At Western Reserve University, the procedures developed by the Center for Documentation and Communication Research for abstracting, encoding and searching technical information (*22*) are to be evaluated in a large-scale test program that got under way at the beginning of 1960. The procedures include the preparation by trained human beings of "telegraphic style" abstracts, consisting of terms and symbols for relationships and functions; the encoding of the resulting abstracts; and searching of the coded information by machine. The encoding procedure and a machine dictionary provide for control of synonyms and certain hierarchical relationships. These procedures are being applied to about 30,000 scientific and technical papers and reports per year in an experimental mechanized searching service for metallurgists. An *ad hoc* committee of metallurgists and information specialists has been named by the National Academy of Sciences–National Research Council to advise on means of evaluating these procedures, either in absolute terms or in comparison with other procedures. Its members can testify to the fact that such evaluation is a very complex undertaking for which there are as yet no tried and true techniques.

Studies in Other Areas

A number of other studies currently in progress do not fall within the research areas discussed thus far. The Electrada Corporation, for example, has undertaken a mathematical analysis of the structure of systems for information storage and retrieval with a view to developing methods for an economic analysis of system design. The corporation has also recently begun a program of exploratory research into file organizations, suitable for extremely large files, with a self-organizing capability and with a number of levels of increasing size and decreasing accessibility.

The University of Pennsylvania Institute for Cooperative Research is also studying file organization and the use of computers to organize files.

The National Bureau of Standards is engaged in mathematical research related to the efficient formulation of search questions for retrieval systems and to means of enabling a mechanized retrieval system to revise its own category structure. The bureau is also experimenting with a machine model of certain verbal selection and recall operations. The model consists of a small vocabulary of terms, stored records of interrelationships between the terms, and routines for various operations, such as "define" and "extend." The aim of the experiments is to determine ways in which machines may be used to speed the selection of stored knowledge and to reformulate search questions in accordance with results obtained.

With respect to the classification of knowledge, the Library Research Circle at Delhi University (*23*) and the Classification Research Group (*24*) which has been meeting in London since 1952 are continuing to study and develop techniques of facet analysis and faceted classification (*21*). In addition to this work, specifically on classification techniques, the various groups working on ways of handling relationships and grouping terms in retrieval systems are also clearly concerned with principles and techniques of classification.

In addition to the work related directly to the improved handling of scientific information, a great deal of research in other fields may produce results relevant to the design of information-handling procedures and systems—fields such as linguistics, logic, mathematics, psychology, neurophysiology, artificial intelligence, communications engineering, and computer programming techniques. It is relevant to note that some universities have established centers or programs in which the knowledge and talents of many disciplines and special fields are enlisted in research on communication problems of all kinds, including those touched on in this article. In discussing (*25*) the establishment of one such center, the Communication Sciences Center of the Massachusetts Institute of Technology, J. B. Wiesner has pointed out that "the fundamental difference between the communication sciences and many other sciences is that, though people in this field may be forced to study physical properties of systems, it is the organizational or structural properties which are of primary concern. Here there are new concepts to understand, and new mathematical tools are required and being created."

Conclusion

By describing current work in the relatively new field of research on the handling of scientific information, I have tried to indicate the present scope and objectives of that work. I hope that this descriptive account also conveys the impression that a great deal more research must be done before we shall know how best to use machines to aid in the handling of information. The possible consequences of such research are of the greatest importance for science. At the very least the research should result in increased understanding of the complex processes of communication among scientists and in improvements in the means for accomplishing such communication and for consulting the record of accumulated scientific knowledge. It may also, however, lead to completely new ways, only dimly foreseen at this time, of using machines to supplement human intelligence in information and communication processes (*26*).

References and Notes

1. G. E. Vleduts, V. V. Nalimov, N. I. Styazhkin, *Soviet Phys.: Uspekhi* (a translation of *Uspekhi Fiz. Nauk*) **2**, No. 5, 637 (1959).
2. *Current Research and Development in Scientific Documentation, Rept. No. 6* (National Science Foundation, Washington, D.C., 1960).
3. R. R. Shaw, *AIBS Bull.* **4**, No. 3, 20 (1954).
4. J. W. Kuipers, A. W. Tyler, W. L. Myers, *Am. Document.* **8**, 246 (1957).
5. A. M. Nelson, "The Research and Development of the Magnacard System," Rept. of Magnavox Co. Research Laboratories (1958) [*WADC (Wright Air Develop. Center) Tech. Rept. No. 58/421; ASTIA Document No. AD 211694*], distributed by Office of Technical Services, U.S. Dept. of Commerce.
6. W. H. Ware, Ed., "Soviet computer technology–1959" (account of a trip in 1959 of U.S. computer experts to the Soviet Union), *IRE Trans. on Electronic Computers* **EC-9**, No. 1, 99 (1960) [also in *Communs. ACM* **3**, No. 3 (1960)]; L. I. Gutenmakher, "Basic directions and trends in the development of digital computer systems in the problem of designing machines and instruments," in *Sovremennyye Napravleniya v Oblasti Konstruirovaniya Tekhnologicheskogo Oborudovaniya* (Contemporary trends in designing technological equipment) (Moscow, 1957) (JPRS translation No. 2276, available from Office of Technical Services, U.S. Dept. of Commerce, OTS 60-11, 319).
7. *Nonconventional Technical Information Systems in Current Use, Rept. No. 2* (National Science Foundation, Washington, D.C., Sept. 1959); suppl. (Mar. 1960).
8. *Documentation, Indexing, and Retrieval of Scientific Information* (Senate Committee on Government Operations, Washington, D.C., 1960).
9. *Am. Psychologist* **14**, 267 (1959).
10. "An Operations Research Study of the Scientific Activity of Chemists," Rept. of the Operations Research Group, Case Institute of Technology, Cleveland, Ohio (1958), submitted to the National Science Foundation.
11. G. M. Dyson, *Chem. Eng. News* **37**, 128 (1959); *ibid.* **38**, 70 (1960).
12. M. E. Maron, *J. Assoc. Computing Machinery* **7**, 216 (1960).
13. L. I. Gutenmakher and G. E. Vleduts, "The

prospects for the utilization of informational-logical machines in chemistry (USSR)," in *Problemy Vysshego Khimicheskogo i Tekhnologicheskogo Obrazovaniya* (Problems of Higher Chemical and Technological Education) (State Publishing House, Moscow, 1959) (paper presented at the 8th Mendeleyev Congress on General and Applied Chemistry; JPRS translation No. R-331-D, 19 Feb. 1960, available from Office of Technical Services, U.S. Dept. of Commerce); A. M. Zuckermann (Tsukerman) and A. P. Terentiev (Terent'yev), "Chemical nomenclature translation," paper presented at the International Conference for Standards on a Common Language for Machine Searching and Translation, Cleveland, Ohio, 1959 (Interscience, New York, in press).

14. T. M. Williams, "From text to topics in mechanized searching systems," "Proc. National Symposium on Machine Translation, Univ. of California, Los Angeles, Feb. 1960" (in press).
15. D. R. Swanson, *Science* **132**, 1099 (1960).
16. H. P. Luhn, *IBM J. Research Develop.* **2**, 159 (1958); T. R. Savage, "The Preparation of Auto-Abstracts on the IBM 704 Data Processing System," *International Business Machines Corp. Rept.* (1958).
17. H. P. Luhn, "Selective Dissemination of New Scientific Information with the Aid of Electronic Processing Equipment," *International Business Machines Corp. Rept.* (1959).
18. Z. S. Harris, "Linguistic transformations for information retrieval," *Proc. Intern. Conf. Sci. Inform.* (National Academy of Sciences–National Research Council, Washington, D.C., 1959), pp. 937–950; A. K. Joshi, "Computation of syntactic structure," in "Proc. Intern. Conf. for Standards on a Common Language for Machine Searching and Translation, Cleveland, 1959" (Interscience, New York, in press); L. Gleitman, "The isolation of elements for grammatical analysis," *ibid.*
19. I. A. Melchuk, *Computers and Automation* **8**, 23 (1959).
20. C. Cleverdon, *Aslib Cranfield Research Project*. The report is available from College of Aeronautics, Cranfield, England (September 1960).
21. In a faceted classification (as distinguished from a hierarchical classification) terms are grouped into categories. B. C. Vickery, in a book entitled *Classification and Indexing in Science* [(Academic Press, New York; Butterworths, London; 1959), p. 12], offers the following explanation: "Instead of trying to construct from the 'original universe' one vast tree of knowledge, facet analysis first groups the terms into categories—kind, state, property, reaction, operation, device and so on—and then arranges the terms within each category into the form of a classificatory map." He points out, for example, that within the field of chemistry, "alcohol" is a *kind* of chemical substance, "liquid" is a *state* of that substance, "volatility" is a *property* of it, "combustion" is a *reaction*, "analysis" is an *operation* performed by man, and "burette" is a *device* for carrying out an operation.
22. J. W. Perry and A. Kent, *Tools for Machine Literature Searching* (Interscience, New York, 1958).
23. S. R. Raganathan, *Depth Classification* (Indian Library Association, 1953); *Ann. Library Sci.* **5**, 33 (1958).
24. "The Need for a Faceted Classification as the Basis of All Methods of Information Retrieval," *Library Assoc. Record* **57**, 262 (1955).
25. J. B. Wiesner, *IBM J. Research and Develop.* **2**, 269 (1958).
26. The Russian transliteration system of the U.S. Board of Geographic Names is used in the Soviet references.

Book Reviews

Arms and Insecurity. A mathematical study of the causes and origins of war. Lewis F. Richardson. Nicholas Rashevsky and Ernesto Trucco, Eds. Boxwood Press, Pittsburgh, Pa.; Quadrangle Books, Chicago, Ill., 1960. xxv + 307 pp. $10.

Statistics of Deadly Quarrels. Lewis F. Richardson. Quincy Wright and C. C. Lienau, Eds. Boxwood Press, Pittsburgh, Pa.; Quadrangle Books, Chicago, Ill., 1960. xlvi + 373 pp. $12.50.

The English physicist and mathematician Lewis F. Richardson (1881–1953) was engaged for many years on the monumental task of constructing a purely objective, mathematical and physical theory of peace and war. These volumes, previously available only on microfilm, are now submitted to the public substantially as Richardson left them. During the author's lifetime only a small sample of his work in this field was published, but this sample included a notable essay entitled "Generalized foreign politics" (1939). *Arms and Insecurity* presents in full a model of armament races and wars outlined in this essay; *Statistics of Deadly Quarrels* takes up the problem of war from a different point of view, also adumbrated in short, early publications.

Arms and Insecurity traces the phenomenon of war to the breakdown of international equilibrium, as evidenced by runaway armament races. Richardson works here with an equilibrium model based upon the idea that changes in one power's military spending over a certain period of time are directly proportional to a potential enemy's actual military expenditures during the same period. The system of interacting powers is at equilibrium when the rate of change in spending is zero for each.

The model specifies the conditions under which such a state of equilibrium can be reached. In fact, the functional relationship between the *change* in *A*'s expenditures over time and *B*'s *actual* expenditures is not such that the former must be positive when the latter is; in other words, it is not the case that *A* is compelled to *increase* his spending as long as *B* spends anything, and vice versa. Rather, the function determining a power's spending differentials contains parameters that can bring the latter down to zero, even when the potential enemy is arming. For example, spending becomes onerous when it rises above a certain level. Having reached that stage, *A* will tend to slow down its armament efforts, and this will have a dampening effect upon *B*'s arming. Richardson postulates, moreover, that the relationship between potential enemies need not be one of pure hostility. While arming against each other, two powers or coalitions can also engage in cooperative activities, such as trade. This will counteract the hostile impulses ("grievances") that induce the powers to arm against each other in the first place. The question in each situation is whether the stimulus for increased spending, that is, spending by the other side, will be sufficiently counterbalanced, by the onerousness of spending and by the prevailing degree of cooperativeness, to result in the stabilization of military expenditures. The volume of trade, serving as a measure of cooperativeness, is crucial in this respect. If it is too small in relation to military spending, the latter will grow to infinity. Such an irreversible trend means war; stabilized military spending means peace.

Richardson's model is deterministic. When the crucial quantities, military spending and trade in particular, show

such and such correlations, war or equilibrium will be the inevitable result. Or rather, the model predicts this inevitable result unless, as Richardson puts it, the policymakers of the powers "stop to think." "Thinking" means, in this context, that the policymakers know Richardson's model and apply their knowledge intelligently, changing certain parameter values under their control so as to avert war.

This type of deterministic model is familiar in applied natural science. One predicts what will "inevitably" happen when certain measurable, variable quantities assume certain values. It is understood, however, that some of the variables are subject to human control. This permits intelligent intervention, steering the course of events in a desired direction. But the deterministic model, as such, yields no prediction whatever about this intelligent intervention itself. In technology, the theory that we work with deals only with phenomena other than our own intelligent, goal-directed decisions. We do not predict what we ourselves will do but only what will happen, depending on whether we do one thing or another.

The *Arms and Insecurity* model attacks the problem of war and peace in this "technological" vein. It yields no predictions about any policymaker's intelligent decisions regarding peace and war. Decisions of this type are envisaged only as a possibility outside the purview of the theory itself. Thus, regardless of whether the model is correct as far as it goes, it cannot be accepted as a theory of peace and war, once it is understood that such a theory must account for meaningful, intelligent war and peace moves. Richardson's theory does not explain war as an institutionalized human activity; nor does it show how political decisions affect the state of equilibrium of a system of interacting powers. It only suggests possible peace policies that have their origin outside the deterministic model with which the theory itself is concerned.

In this connection, Richardson has done fine destructive work on some rationalizations prevalent in political discourse—for example, that a proposed increase in armaments is both necessary and sufficient to maintain peace, and that a proposed increase serves no other purpose than that. His devastating critique of such notions is eminently useful in enforcing honesty in discourse, compelling statesmen to admit that peace is not their *only* objective. But once honesty is restored and the existence of objectives other than peace is admitted, thinking about war and peace must go beyond the model of *Arms and Insecurity* with its "technological" orientation.

Richardson himself adopts a radically different approach in his second study, *Statistics of Deadly Quarrels*. Here he treats war as a statistical phenomenon, subsuming it under a broader category, that of the "deadly quarrel": murders, riots, civil disturbances, and the like, as well as large-scale revolutions and wars. Richardson breaks this over-all category into subclasses according to the "magnitude" of quarrels—that is, the logarithm of the number of deaths caused by each—and examines the statistical distribution of the various subclasses.

The basic idea underlying Richardson's statistical treatment of war consists of constructing a framework of equal physical opportunities for fighting and then of finding out from the record whether wars have been "random" occurrences in the sense that the same number of physical opportunities has always been associated with the same frequency of wars in every part of the universe. The implication is that where significant deviations from a uniform frequency are found, one has to assume the presence of some factor specifically related to warlikeness and peacefulness, respectively.

Richardson's analysis of an enormous collection of data leads to the conclusion that the assumption of randomness indeed represents a good first approximation. At least, he finds no statistical support for hypotheses asserting either a clear-cut temporal trend toward more (or fewer) wars or the existence of few villains, "warlike" nations responsible for a disproportionately large number of wars. Concerning religious and economic factors, his conclusion is also fairly skeptical. Only a relatively small proportion of wars can be traced to economic causes, and while religious differences did lead to more wars between Christians and Moslems than one would have expected on the basis of sheer physical opportunity, the two groups' propensity for fighting each other has not been stable.

Still, Richardson finds enough deviations from a uniform frequency of wars (given equal physical opportunities) to reject the hypothesis of pure randomness. Thus, he finds that the probability of any nation's going to war goes up when *others* are fighting: fighting is "infectious." On the other hand, governments exert a local "pacifying" influence: with the same physical opportunities for fighting, groups living under the same government are less likely to engage in "deadly quarrels" among themselves than they are to fight outsiders. Richardson considered this to be the most vital conclusion suggested by his statistical study; it pointed to world government as the most promising solution of the problem of war.

Political scientists are apt to find this last revelation vacuous. To them it is axiomatic that the existence of governmental authority extending over a domain means a significant degree of peace and order. The question is not *whether* uncontested governmental authority exerts a pacifying influence but *how* governmental authority is established and maintained, or, respectively, challenged and undermined. In this respect, then, starting from uniform physical opportunities and noting deviations from a random pattern of fighting merely helps us discover something obvious; it does not significantly increase our knowledge of peace and war. Some other parts of Richardson's statistical analysis, however, are extremely instructive; here too, he is most effective in demolishing tendentious political myths, such as that of the "aggressor nations."

The greatest significance of Richardson's work lies not in his conclusions but in his determination to analyze the phenomenon of war purely in terms of objective, factual, measurable data, eschewing all subjective interpretations. Both his industry in collecting a comprehensive array of factual material and his virtuosity in the mathematical treatment of the data are truly stupendous. To be sure, a satisfactory objective treatment of political phenomena, such as war, is not possible as long as we have no mathematical models powerful enough to encompass intelligent behavior in complex real-life situations, and it is not clear, at this point, whether such models can be constructed. But in any case, it is desirable to develop the objective approach as far as possible, and Richardson's monumental work is an important landmark in this quest.

PAUL KECSKEMETI
RAND Corporation, Washington, D.C.

Advanced Organic Chemistry. G. W. Wheland. Wiley, New York, ed. 3, 1960. xi + 871 pp. Illus. $17.50.

This edition of a well-known textbook contains new material considered by most instructors to be necessary for the study of organic chemistry at the graduate level. Among the new topics introduced are electron and nuclear magnetic resonance, the Hammet equation, selected kinetic studies, and molecular orbital theory. The text is improved by the additions, but the brief treatments accorded the topics here could hardly give the student any proficiency with concepts and techniques considered by many to be essential for understanding current developments in the theory and practice of organic chemistry.

RICHARD H. EASTMAN
Department of Chemistry,
Stanford University

Soviet Statistics of Physical Output of Industrial Commodities. Their compilation and quality. Gregory Grossman. Princeton University Press, Princeton, N.J., 1960. xvi + 150 pp. $4.50.

Gregory Grossman has a deservedly high reputation among those interested in the Soviet economy. His work is always interesting and stimulating, it avoids jargon, it shows scholarship and ingenuity in handling evidence. All these qualities are present in this volume. He delimits his area of inquiry quite clearly: *physical* output of industrial commodities. Therefore, he does not analyze output indices, or agricultural statistics, for example. Within his chosen area, he goes carefully into all available evidence, taking nothing for granted, never making unproved assertions. If his conclusions are sometimes tentative, this is because the evidence is often tenuous, or even contradictory. On the whole, he tends to the sensible view that the data on physical output, as reported, are usable, that there is probably no "double book-keeping" in the sense of a separate working set of "unfalsified" figures used by the planners. On the other hand, some false reporting from below undoubtedly occurs, while central statisticians sometimes endeavor to mislead by selection and suppression of data. Grossman warns us that these hypotheses rest on a not-very-sure foundation; however, the pure invention hypothesis, which he calls the "nihilistic position," is much less well founded.

There are some very interesting analyses of possible forms of distortion in reporting to the center and of the measures taken to combat it. It is true and important that some forms of falsification are much easier to practice than others. For instance, it is hardly possible to "invent" the production of nonexistent steel, because the factory concerned would be called upon to deliver it to somebody. The factory may, however, "borrow" production from the first week of the next plan period to enable it to claim plan fulfilment for the current period. It may alter the product mix, to the disadvantage of the users, for the same reason. The extent to which a factory can do such things depends on the degree of detail of the plan, the number of possible variants of the product, the importance attached to it by inspecting and checking agencies, and so on. The reporting agencies tend to be interested in presenting their statistics so as to show rapid growth, and they use the ambiguities of the regulations to this end. The chronic seller's market has often enabled the producer to foist inferior or defective products on the purchaser, and thereby to inflate output figures. All these and other factors are discussed fully and well. "Presentational" distortions in publication by the central statistical administration are also well covered, and the attentive reader will learn to be cautious in evaluating certain types of data, without jumping to the conclusion that outright falsification is practiced. Thus, an output series on footwear production may be affected by an unpublicized change of the definition of "leather shoes" or by the omission of the production figures for some small workshops during the base-year, but there is no evidence that the authorities simply announce that 250 million pairs have been produced when they know the correct figure to be 230 million. Again, "definitional" distortions depend on the commodity. What might be possible in the case of shoes, clothes, or canned foods is most unlikely to apply to other items—for example, electricity or flour —which are much more homogenous.

Possibly the author is a little hard on Soviet statistics and statisticians, at least by implication, when he compares them with our own. In my days at the British Board of Trade, I was struck by the reluctance of many firms to supply information, other than during infrequent (and much resented) censuses of production. The necessities of planning do provide a flow of regular data and the means of administrative cross-checking, which Western statistical agencies lack. Many of the statistical problems, notably those involved in physical output data of multivariant commodities, are common to all countries, and a perfectly "correct" answer is beyond the wit of man. But it is an important fact that the self-interest of Soviet enterprises and reporting agencies is involved in a way in which it is not in the West, and it would be surprising indeed if this self-interest did not affect the figures. In analyzing the various ways in which this would affect published data, Gregory Grossman has produced a most valuable survey of a very important and complex aspect of evaluating Soviet statistics.

A. NOVE
London School of Economics,
University of London

Relativity: The General Theory. J. L. Synge. North-Holland, Amsterdam; Interscience, New York, 1960. xvi + 506 pp. Illus. $16.50.

This book is the sequel of Synge's work *Relativity: The Special Theory*, which was published by the same publishers in 1956. The present book may be considered a text or a monograph; at any rate it is a very personal account of the subject matter, in the best sense of the word, and makes most enjoyable reading for the fellow investigator.

This work is distinguished from other books on general relativity by its geometric approach. Synge takes the Riemannian character of the space-time continuum for granted, but then makes a most searching inquiry into the possibility of invariant characterization of diverse four-dimensional manifolds, most but not all of which are presumed to possess some interest to the physicist. That much of the book is written in an informal, and occasionally episodal, style should not deceive the casual reader into believing that Synge has written a semipopular work. Quite on the contrary; Synge deals with a number of topics that are now subjects for research, and he goes to the bottom of many of them. If his presentation occasionally leaves one dissatisfied, it is because the subject has not yet been completely clarified.

Among other topics, Synge has dealt with continuum mechanics, the Cauchy problem of general relativity, integral conservation laws and equations of motion, fields with special symmetries, gravitational waves, solutions of the Einstein-plus-Maxwell field equations, and geometrical optics in a curved universe.

For the record I should like to state that Synge's criticism of a statement of mine (see page 310, footnote 1) is fully justified.

PETER G. BERGMANN
Department of Physics,
Syracuse University

North Arabian Desert Archaeological Survey, 1925–50. Papers of the Peabody Museum of Archaeology and Ethnology, vol. 45, No. 2. Henry Field. Peabody Museum, Harvard University, Cambridge, Mass., 1960. x + 224 pp. Illus. $8.25.

In southwestern Asia few regions are so little known archeologically as the Arabian Peninsula, where serious lacunae remain in our knowledge of the cultural history of every area and of every period. Some of the gaps in the prehistory of northern Arabia are filled by this work, which contains the results of five ground surveys and one aerial crossing of the North Arabian (or Syrian) Desert, conducted by Field between 1925 and 1950.

While these surface surveys by no means covered the entire region, they yielded a sufficiently representative sampling of artifacts to permit the distinguished prehistorian Dorothy Garrod to frame tentative conclusions regarding the cultural history of the region in prehistoric times. The Paleolithic period is successively represented by Acheulean, Levalloisian, Levalloiso-Mousterian, and Aurignacian industries, with affinities to those of neighboring countries, especially Syro-Palestine. Thereafter the desert cultures apparently diverge from surrounding tradition, and Garrod typologically distinguishes three industries ranging in time from the late Paleolithic—early Mesolithic to the late Mesolithic–Neolithic. The exact nature and chronological order of these late industries must await the discovery and excavation of stratified sites. In Paleolithic times, this region seems to have enjoyed a more favorable climate, supported a larger population, and served as a route of migration between Africa and Asia. The absence of sickle blades from the latest industries suggests that desiccation was sufficiently advanced in Mesolithic times to make agriculture impossible.

Other essays deal with special features of the survey. The geology of the region is described by E. W. K. Andrau; the architecture of three Umayyad lodges is discussed by Eric Schroeder, supplemented with observations by Florence E. Day; and a Greek inscription from Qasr Burqu' is published by Sterling Dow. Appended to the report are two lists of plants from this region and a most useful list of the archeological sites visited, with a summary of the finds at each. Worthy also of special notice is the excellent three-color map showing Field's traverses, the sites and quarries discovered, and the surface features of this region. This book will be an extremely useful source for future archeological research in the region.

GUS W. VAN BEEK
U. S. National Museum,
Smithsonian Institution

The Economics of Defense in the Nuclear Age (A RAND Corporation research study). Charles J. Hitch and Roland N. McKean, Eds. Harvard University Press, Cambridge, Mass., 1960. vii + 422 pp. $9.50.

This book deals not primarily with economics, as it is ordinarily understood, but with the application of economic concepts to military decision-making at all levels. The authors "regard all military problems as, at least in one of their aspects, economic problems in the efficient allocation and use of resources." They feel that "the job of economizing, which some would leave to budgeteers and comptrollers, cannot be distinguished from the whole task of making military decisions."

Starting from this premise, the authors discuss first the general background of defense planning: the various military threats we face, the general economic-resource limitation of defense programs, the indirect effects of defense spending, and the economic strengths of the major powers.

The major portion of the book is devoted to describing and illustrating concepts and methodology for making quantitative analyses of cost versus effectiveness of alternative military programs, sometimes in dollar measures, often in physical measures, when time or other constraints require it. One excellent chapter discusses the problems of selecting appropriate criteria for evaluating the relative effectiveness of alternative programs, a particularly knotty problem in most large-scale systems analyses, particularly when various incommensurable costs or benefits are involved.

Also discussed are the difficult problems of handling uncertainty, both for the case of random variation and for uncertainty resulting from the future decisions of an enemy, who is likely to take advantage of any weakness in our defense posture. An appendix, written for readers with an elementary knowledge of differential calculus, "presents necessary and sufficient conditions for the maximum and minimum of a broad class of functions. It also includes a brief discussion of methods for finding the maximum."

Numerous examples to illustrate the concepts discussed are drawn from the Rand Corporation's 15 years of experience in analyzing, for the Air Force, problems at all levels, ranging from the broad strategy for deterring all-out war to the design of efficient logistic support procedures.

In part 2 the discussion covers a variety of special problems and applications: efficiency in military research and development; military logistics; the economics of military alliance; economic warfare and disarmament; mobilization, civil defense, and recuperation. The final chapter "Choosing policies for deterrence," is a reprint of Albert Wohlstetter's brilliant article, "The delicate balance of terror," which first appeared in the January 1959 issue of *Foreign Affairs*.

The book is well and simply written, and presupposes no special background in economics, mathematics, or operations research. The authors disclaim any intention of writing a text in "how to do" military operations research or systems analysis; but it is, in fact, one of the best general expositions of concepts in these fields which has appeared. It should be useful to military operations analysts, and invaluable to decision-makers who must use the results of military operations analysis and system analysis. It would make an excellent text for use in the service war colleges and in university courses in operations analysis.

MARSHALL K. WOOD
National Planning Association,
Washington, D.C.

New Books

Biological and Medical Sciences

Advances in Biological and Medical Physics. vol. 7. Cornelius A. Tobias and John H. Lawrence, Eds. Academic Press, New York, 1960. 371 pp. Illus. $10.

Advances in Clinical Chemistry. vol. 3. Harry Sobotka and C. P. Stewart, Eds. Academic Press, New York, 1960. 413 pp. Illus. $12.

Chemobiodynamics and Drug Design. F. W. Schueler. McGraw-Hill, New York, 1960. 652 pp. Illus. $19.50.

Classics in Biology. A course of selected readings. Philosophical Library, New York, 1960. 381 pp. $6.

Clinical Inference and Cognitive Theory. Theodore R. Sarbin, Ronald Taft, and Daniel E. Bailey. Holt, Rinehart and Winston, New York, 1960. 303 pp. $5.50.

Comparative Biochemistry. A comprehensive treatise. vol. 1, *Sources of Free Energy*. Marcel Florkin and Howard S. Mason, Eds. Academic Press, New York, 1960. 616 pp. Illus. $18.

Comparative Effects of Radiation. Milton Burton, J. S. Kirby-Smith, and John L. Magee, Eds. Wiley, New York, 1960. 446 pp. Illus. $8.50. Report of a conference held at the University of Puerto Rico, 15–19 February 1960, sponsored by the National Research Council—National Academy of Sciences.

Developments in Industrial Microbiology. vol. 1. Plenum Press, New York, 1960. 276 pp. Illus. $7.50. Proceedings of the 16th general meeting of the Society for Industrial Microbiology.

Electrical Studies of the Unanesthetized Brain. Estelle R. Ramey and Desmond S. O'Doherty. Harper, New York, 1960. 436 pp. $6.

Endemic Goitre. F. W. Clements *et al.* World Health Organization, Geneva, Switzerland, 1960. 471 pp. $8. Contributions by 18 authors from 10 countries provides a review of the subject and includes information on history, prevalence, and geographical distribution.

Epidemiologic Methods. Brian MacMahon, Thomas F. Pugh, and Johannes Ipsen. Little, Brown, Boston, Mass., 1960. 314 pp. $7.50.

Flora of the British Isles. *Illustrations*. pt. 2, *Rosaceae-Polemoniaceae*. A. R. Clapham, T. G. Tutin, and E. F. Warburg. Cambridge Univ. Press, New York, 1960. 124 pp. Illus. $5.

General Cytology. E. D. P. De Robertis, W. W. Nowinski, and Francisco A. Saez. Saunders, Philadelphia, Pa., ed. 3, 1960. 571 pp. Illus. $10.

Handbook of Microbiology. Morris B. Jacobs and Maurice J. Gerstein. Van Nostrand, Princeton, N.J., 1960. 332 pp. $8.50.

The Human Blood Proteins. Methods of examination and their clinical and practical significance. Ferdinand Wuhrmann and Charlie Wunderly. Translated by Harvey T. Adelson from the completely revised ed. 3. Grune and Stratton, New York, 1960. 502 pp. Illus. $15.75.

Human Growth. vol. 3 of the symposia of the Society for the Study of Human Biology. J. M. Tanner, Ed. Pergamon, New York, 1960. 127 pp. Illus. $5.

Hypnosis in Treatment. William Moodie. Emerson Books, New York, 1960. 168 pp. $4.

Lipids and the Steroid Hormones in Clinical Medicine. Proceedings of an applied seminar of the Association of Clinical Scientists. F. William Sunderman and F. William Sunderman, Jr. Lippincott, Philadelphia, Pa., 1960. 217 pp. $10.75.

Lymphatics and Lymph Circulation. Physiology and pathology. Istvan Rusznyak, Mihaly Foldi, and Gyorgy Szabo. Translated by Andras Deak and Jozsef Fesus. Pergamon, New York, 1960 (Hungarian ed. 1, 1955; German ed. 2., 1957; Russian ed. 3, 1957). 853 pp. Illus. $20.

Man and His Body. The wonders of the human mechanism. Benjamin F. Miller and Ruth Goode. Simon and Schuster, New York, 1960. 381 pp. $5.95.

Medical and Biological Research in Israel. Moshe Prywes, Ed. Hebrew Univ. of Jerusalem and Hadassah, 1960 (order from Grune and Stratton, New York). 582 pp. $8.

Metabolic Pathways. vol. 1. David M. Greenberg, Ed. Academic Press, New York, ed. 2, 1960 (ed. 2 of *Chemical Pathways in Metabolism*). 587 pp. Illus. $18.

Modern Insecticides and World Food Production. F. A. Gunther and L. R. Jeppson. Wiley, New York, 1960. 299 pp. Illus. $8.50.

Nematology. Fundamentals and recent advances with emphasis on plant parasitic and soil forms. J. N. Sasser and W. R. Jenkins. Univ. of North Carolina Press, Chapel Hill, 1960. 495 pp. Illus. $12.50.

An Outline of Chemical Genetics. Bernard S. Strauss. Saunders, Philadelphia, 1960. 198 pp. Illus.

The Plasma Proteins. vol. 2, *Biosynthesis, Metabolism, Alterations in Disease*. Frank W. Putnam, Ed. Academic Press, New York, 1960. 534 pp. Illus. $14.50.

Polysaccharides of Micro-organisms. M. Stacey and S. A. Barker. Oxford Univ. Press, New York, 1960. 240 pp. Illus. $4.80.

Problems in Photosynthesis. W. Bladergroen. Thomas, Springfield, Ill., 1960. 211 pp. $10.50.

Progress in Experimental Tumor Research. F. Homburger, Ed. Lippincott, Philadelphia, Pa., 1960. 491 pp. $22.

Radioactive Isotopes in Biochemistry. Engelbert Broda. Elsevier, Amsterdam, 1960 (order from Van Nostrand, Princeton, N.J.). 386 pp. Illus. $11.50. Original title was *Radioaktive Isotope in der Biochemie* (1958); translated by Peter Oesper.

Rudolf Virchow Medical Society in the City of New York, N.Y. Joseph Berberich, Henry Lax, and Rudolf Stern, Eds. Karger, New York, 1960 (order from Albert J. Phiebig, Box 352, White Plains, N.Y.). 531 pp. $16. Jubilee volume on the 100th anniversary of the society; contains a 35-page history of the society (by K. F. Hoffmann), 28 papers, and a list of the past presidents and of the officers for 1960.

Sea Within. The story of our body fluid. William D. Snively, Jr. Lippincott, Philadelphia, Pa., 1960. 160 pp. Illus. $3.95.

A Synopsis of Biology. W. B. Crow. Wright, Bristol, England; Williams and Wilkins, Baltimore, Md., 1960. 1071 pp. Illus. $17.

A Textbook of Clinical Pathology. Seward E. Miller, Ed. Williams and Wilkins. Baltimore, Md., ed. 6, 1960. 915 pp. Illus. $15.

Toxic Phosphorus Esters. Chemistry, metabolism, and biological effects. Richard D. O'Brien. Academic Press, New York, 1960. 446 pp. $14.50.

Transactions of the Society of Rheology. vol. 4, 1960. E. H. Lee, Ed. Interscience, New York, 1960. 368 pp. $10.

Ultrafiltration. L. Ambard and S. Trautmann. Thomas, Springfield, Ill., 1960. 77 pp. $4.50.

Wonder-Workers of the Insect World. Hiram J. Herbert. Dutton, New York, 1960. 160 pp. Illus.

The Wonders of Life on Earth. By the Editors of *Life* and Lincoln Barnett. Time Inc., New York, 1960. 300 pp. Illus. $12.50. This magnificently illustrated volume, a companion to *The World We Live In*, is drawn from articles published in *Life* from 1957 to 1959, but many of the pictures and illustrations are published for the first time. In the introduction the career of Charles Darwin is evaluated by Sir Julian Huxley, distinguished British scientist and grandson of the famous biologist, Thomas Henry Huxley, who was Darwin's contemporary champion.

Economics and the Social Sciences

Attitude Organization and Change. An analysis of consistency among attitude components. Milton J. Rosenberg *et al.* Yale Univ. Press, New Haven, Conn., 1960. 251 pp. $5.

Becoming More Civilized. A psychological exploration. Leonard W. Doob. Yale Univ. Press, New Haven, Conn., 1960. 345 pp. $6.

The Central Nervous System and Behavior. Mary A. B. Brazier, Ed. Josiah Macy, Jr. Foundation, New York, 1960. 475 pp. Illus. $7.50. Transactions of a conference held 21–24 February 1960 at Princeton, N.J.

Energy in the American Economy, 1850–1975. An economic study of its history and prospects. Sam H. Schurr and Bruce C. Netschert. Published for Resources for the Future, Inc., by Johns Hopkins Press, Baltimore, Md., 1960. 796 pp. Illus. $12.50.

Land in British Honduras. Report of the British Honduras land use survey team. Colonial Research Publ. No. 24. D. H. Romney, Ed. Her Majesty's Stationery Office, London, 1959. 335 pp. Illus. + maps. 55s.

Nebraska Symposium on Motivation, 1960. Marshall R. Jones, Ed. Univ. of Nebraska Press, Lincoln, 1960. 279 pp. Paper, $3.25; cloth, $4.25.

Political Science. A philosophical analysis. Vernon Van Dyke. Stanford Univ. Press, Stanford, Calif., 1960. 250 pp. $5.

The Psychology of Character Development. Robert F. Peck and Robert J. Havighurst. Wiley, New York, 1960. 286 pp. $6.50.

The Structure of the East German Economy. Wolfgang F. Stopler. Harvard Univ. Press, Cambridge, Mass., 1960. 503 pp. $10.

On Thermonuclear War. Herman Kahn. Princeton Univ. Press, Princeton, N.J., 1960. 671 pp. $10.

Science in the News

U.S. Assistance to Latin America: Politics, Rather than Technology, Determines What Is Most Useful

Within the State Department the feeling has been growing steadily that the question of what are the most useful types of economic and technical and educational aid the United States can grant to the Latin American countries is essentially political. The immediate problem, in this view, is not what can be done to help the long-range plans for industrializing these countries, the only ultimate answer to the poverty of the masses of the people, but what can be done to strengthen the position of governments that would like to go through with long-range development plans through democratic rather than totalitarian means. Political realities have led to an increasing belief in the importance of aiding Latin-American governments to put through elementary programs of social reform as opposed to strengthening the technology and higher education which are really more pertinent in the long run.

The political situation in Latin America that forces this conclusion is outlined below. Once the conclusion has been reached there is the further political problem of making it effective; for it is not hard at all to get Congress to vote for military aid to a Latin American dictator who promises to keep the communists out; it is not too hard to get Congress to vote for advanced technical assistance where it is easy to demonstrate how such investments will pay off in the future; the most difficult thing to do is to get Congress to go along with a program that is aimed primarily at such things as building houses for Peruvian peasants and teaching adult illiterates how to read enough to get through a tabloid newspaper.

The Political Problem

The communists and procommunists who are so easy to run across in Havana these days are glowing with confidence that Castroism will sweep over Latin America in the next few years, and although their confidence is greater than it ought to be, its basis is easy to understand.

Their belief is that in all of these countries there exists a conservative ruling class supported by foreign investors interested only in a stable government that will allow them to run their businesses without interference; that the existence of these forces, combined with a tradition of revolution, tends to lead to a rightist coup, overthrowing any liberal regime that tries to put through a real program of reform.

The communists, and a disturbingly large number of noncommunists, are convinced that the only choice for progressive interests is to follow the example of Russia, turning to a dictatorship of the left, which, whatever may be said against it, has demonstrated that at a price it can industrialize and modernize a nation.

Perfect illustrations of the problem are available in Cuba and San Salvador. The situation has led, in Cuba, to the formation of a government which insists, through Castro, that the mass of the Cuban people and the revolutionary government are the same thing, that it is impossible to attack the government without damaging the Cuban people, and that therefore anyone who opposes the government is a traitor to the Cuban people and must be stifled by the government in the name of the people's revolution.

The mass of the Cuban people readily accept this argument, for they look at what Castro has done for them and compare it with what Batista did to them and it seems, even to a great many of the more sophisticated Cubans, that Fidel Castro is doing only what the mass of the Cuban people want done and that it is indeed impossible to oppose him without damaging the interests of the Cuban people. As a result, and despite mounting indications that his regime, like that of Russia, will require a long period of austerity and repression in order to industrialize the nation, his popular support remains so strong that a successful counterrevolution is unthinkable at this time.

In contrast to this, a government in San Salvador which attempted to begin a program of liberal reform was toppled this month by a combination of the extreme right, which wanted no reform, and the extreme left, which assumes, quite correctly, that the way to a Castro-type revolution is to make sure that a middle-of-the-road government fails.

The hope for democratic reform in South America, it is generally agreed, lies in the increasing recognition of the nature of the problem within the U.S. Department of State and, more slowly, elsewhere within the American government and within the ruling oligarchies of the South American countries.

The Act of Bogota, signed last September by 21 Latin-American nations, and for which Under-Secretary of State Douglas Dillon, Kennedy's appointee as Secretary of the Treasury, deserves a great share of the credit, amounts to recognition that elementary social reforms that will win for a government the broad support of the people must take precedence over the technological and advanced educational programs that will eventually be needed to modernize these countries.

A real program of development necessarily requires, for one thing, a drastic rise in tax rates, which in every Latin-American country are now far below those in any of the more developed countries. As Castro has demonstrated, a government with really strong popular support can actually confiscate the property of the wealthier classes, while a government without such popular support cannot even begin to raise taxes, or even try to collect taxes that are already on the books, without being overthrown.

The sort of reforms the Act of Bogota recognizes as necessary "to meet the legitimate aspirations of the peoples of the Americas for a better life" are very much the sort of thing that won Castro the support that has enabled him to insist that anyone who questions what he is doing is a traitor and that has given the Castro government the power to take complete con-

trol of everything it chooses to control in Cuba, and in the case of land, housing, and the larger businesses actual, if not apparent, ownership of these sectors of the economy. (Some large businesses are merely "intervened," meaning that their operation is in the hands of the government, but that they are still, in a technical sense, privately owned; many of the field workers have been given certificates of title to a few acres, but the government keeps the right to tell them what to plant, how to grow it, and where to market it, and they have no way either to sell the land they "own" or to buy more. In the case of all rented housing, payments to the government are considered payments toward ownership of the home, but even with the oldest homes it will be 5 years before anyone will know what rights, if any, ownership involves.)

Castro has had no serious trouble putting through such programs. His support in fighting Batista came largely from the very people in the middle and upper classes who now feel betrayed by the revolution. But as he prepared to move against his original supporters he won mass support by demonstrating that his government was something entirely different from anything they had ever known, or even realized was possible; a government that really intended to do something for the common people: he began replacing the mud huts of the field workers with real homes; he built schools where there had never been schools; he opened the beaches to a people that had always accepted the idea that the right to spend a day at a pleasant beach was a privilege available only to the wealthy; he built pleasant parks for people who never knew such things existed. With such accomplishments he won the absolute confidence of enough of the mass of the people to give him a free hand to do whatever else he cared to do.

The Act of Bogota talks of very much the same sort of things: schools, literacy campaigns, low-cost housing, roads in the country districts to make it easier for the small farmer to bring his produce to market. None of these things, any more than any of Castro's original reforms, contributes much to real economic development, but a government that has done such things can win the mass support to put through, if it wants to, both more social reforms and tax and other policies to speed economic development.

This set of political realities in Latin America implies that American aid, for the present, ought to be directed not toward helping these countries industrialize, but first toward winning mass support for a progressive government before a revolution of the extreme left does so. Castro was able to move without being toppled at the start because of his prestige as the hero of the revolution and his really remarkable gifts as a mass orator. The new United States policy toward Latin America, not yet put into effect, but with its intentions embodied in the terms of the $500 million fund put through Congress last summer, is to give democratic governments in Latin America a chance to win mass support without being toppled at the beginning. The method is simply to finance the first steps of reform almost entirely from the United States, making it unnecessary to begin doing things that attack the position and wealth of the oligarchy until mass support has been won.

The terms used here are a good deal blunter than anything the State Department will use officially. Compared with what the communists think is necessary, it is very mild. But compared with what conservatives, either in the United States or in South America, would like this country to do, it is literally revolutionary; it is consciously aimed at undermining the power of the established ruling classes, as well as that of long-established American business interests. But as Senator Kennedy keeps saying, we live in a revolutionary world; the only question in the underdeveloped countries is whose revolution will win, ours or the communists'.

Opposition Certain

The opposition to be expected will come first, of course, from the established oligarchies, who are at least partially aware that once a program of social reform is begun it will win for the government mass support that threatens their own position. The arguments used against beginning any such reforms are two fairly contradictory ones: the argument familiar in the United States during the 1930's that any program of social reform is a step toward communism, and the argument that the people really are not interested in such reforms. Even in Cuba today, where one need only look around him to see how much support such social reforms have won for Castro, it is still fairly easy to find upper class Cubans and old-school Western diplomats who insist that the Cuban field worker really preferred his mud hut to the houses the government is building for him.

Both of these arguments are used to oppose, in many countries, any real programs of reform even when the United States government is willing to finance them.

The situation in Cuba is helping to get across the idea that the only real choice is between a peaceful New Deal type of revolution and a violent upheaval. The State Department has instructed American ambassadors in Latin America to be as forceful as possible in getting across the idea that, if democratic forces are not permitted to gain mass support, a Castro will; yet no matter how unassailable the logic that leads to this position, a great many people satisfied with things as they are find it much easier, much more agreeable, simply to close their eyes and pretend that tomorrow will never come.

Meanwhile there is the political problem within the United States where there is unfortunately more truth than we normally like to admit to Castro's charges that American policy in Latin America has been determined not by what the American people would like to see done but by what American corporations with investments in Latin America would like to see done. The problem has been that until quite recently about the only people who were making a major effort in influencing Latin American policy were corporations with large foreign investments. Many of the companies that have recently moved into Latin America are quite liberal in their attitudes, but the old, well-established investors share the same point of view as the conservative Latin American oligarchies, and it is these older companies that enjoy a long-established connection with key Congressional chairmen and the old-school element in the foreign service.

The influence of these forces was illustrated in the complete failure of Eisenhower's attempt, during the rump session of Congress, to get authority to cut the Dominican Republic sugar quota. The biggest headlines produced by this attempt to demonstrate that the United States is opposed to dictatorships of the right as well as to those of the left were those based on Senator Ellender's remark that he thought that it would be a good thing to have a Trujillo in every country in Latin

America. Ellender is chairman of the Senate Agriculture Committee, which has authority over sugar legislation.

The task of overcoming these entrenched political forces will fall on Kennedy. For it is only the President who commands the position and prestige to quickly mobilize general support for policies in an area where entrenched special, rather than national, interests have long held a controlling influence. —H.M.

News Notes

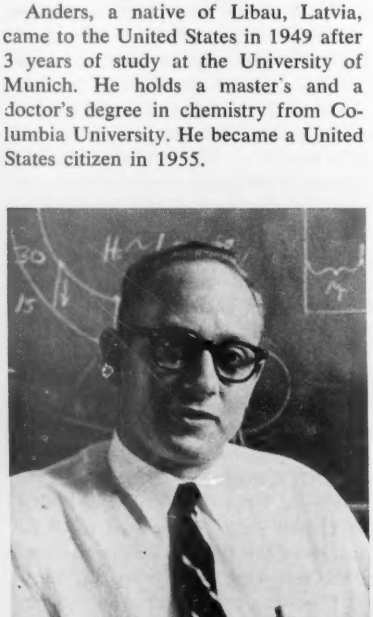
Four Major AAAS Awards Presented at Association's New York Meeting

The American Association for the Advancement of Science presented four major awards during its 127th annual meeting this week in New York.

Newcomb Cleveland Prize

Edward Anders, associate professor of chemistry at the University of Chicago, is the 32nd recipient of the $1000 AAAS Newcomb Cleveland Prize, the Association's senior award, given for "a noteworthy paper, representing an outstanding contribution to science." Anders's prize-winning work, which established a new and direct link between meteorites and asteroids, was selected from the papers delivered at last year's AAAS meeting in Chicago.

Anders, a native of Libau, Latvia, came to the United States in 1949 after 3 years of study at the University of Munich. He holds a master's and a doctor's degree in chemistry from Columbia University. He became a United States citizen in 1955.



Edward Anders, Newcomb Cleveland Prize

Anders conducted research at Brookhaven National Laboratory in 1954 and was an instructor in chemistry at the University of Illinois from 1954 to 1955. He joined the faculty of the University of Chicago as an assistant professor of chemistry in the Enrico Fermi Institute in 1955 and was appointed associate professor in 1960. Last spring he was visiting professor of geochemistry at the California Institute of Technology. He is also a consultant to the theoretical division of the Goddard Space Flight Center of the National Aeronautics and Space Adminstration.

Anders began his research activities in the field of radiochemistry. After spending nearly 6 years on an unsuccessful search for the 43rd element, technetium, in nature, he shifted his interest to cosmochemistry, particularly meteorites. Support for his work has come from the U.S. Atomic Energy Commission and the National Science Foundation.

Upon receiving the award on Monday at New York's Commodore Hotel, Anders delivered an address on recent work on meteorites, in a general symposium on "Moving Frontiers of Science."

The Newcomb Cleveland Prize has been administered by the Association since 1923, when it was established by the late Newcomb Cleveland of New York. A life member of the Association, he preferred to remain anonymous until his death in 1951. With his bequest of $25,000, the AAAS continues to make the award in his name.

Theobald Smith Award

Richard J. Havel, associate professor of medicine and staff member of the Cardiovascular Research Institute, University of California School of Medicine, San Francisco, has won the 1960 AAAS Theobald Smith Award in Medical Sciences for his work in intermediary and lipoprotein metabolism. The $1000 award, which was established in 1936 by Eli Lilly and Company, is given to an investigator under 35 who has "demonstrated research in the field of medical sciences, taking into consideration independence of thought and originality."

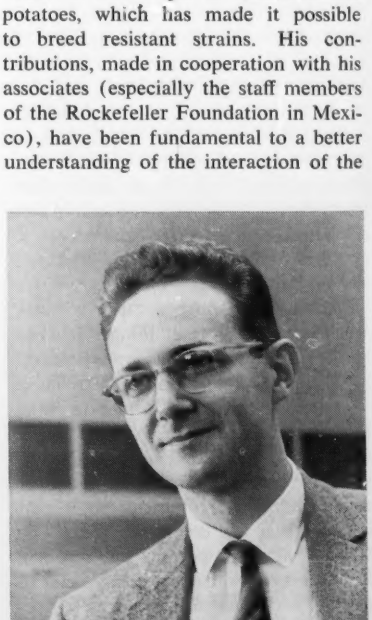
Havel graduated from Reed College and received M.S. and M.D. degrees from the University of Oregon. He then spent 4 years as intern and resident at New York Hospital. After serving as instructor in medicine at Cornell University Medical College, and then as clinical associate at the National Heart Institute, he assumed his present post in California.

Havel's early work was concerned with ways of producing heparin-like activity in serum, and with the structural requirements for heparin-like activity. Later studies were devoted to the effects of fat ingestion, of fasting, and of carbohydrate ingestion on lipids and lipoproteins of human serum. Havel's most recent experiments have led to his proposal of the concept that the sympathetic nervous system exerts a controlling action on the mobilization of fatty acids from adipose tissue which may be altered by central stimuli as well as by hormonal factors.

Havel's investigations have had significance for the field of atherosclerosis and heart disease. The American Heart Association awarded him an Established Investigatorship for his early work.

Campbell Award

M. E. Gallegly, Jr., professor of plant pathology at West Virginia University, has won the $1500 AAAS Campbell Award for Vegetable Research, which was established 3 years ago by the Campbell Soup Company to recognize research of either fundamental or practical significance to the production of vegetables for processing purposes. Gallegly was honored for his work on late blight in tomatoes and potatoes, which has made it possible to breed resistant strains. His contributions, made in cooperation with his associates (especially the staff members of the Rockefeller Foundation in Mexico), have been fundamental to a better understanding of the interaction of the



Richard J. Havel, Theobold Smith Award

M. E. Gallegly, Jr., Campbell Award

Robert Rosenthal, Socio-Psychological Prize

host pathogen in the disease, incited by *Phytophthora infestans.*

Gallegly received a B.S. degree in agriculture from the University of Arkansas and M.S. and Ph.D. degrees from the University of Wisconsin. He has been at West Virginia University since 1949.

Socio-Psychological Prize

Robert Rosenthal, associate professor of psychology at the University of North Dakota (at present on leave to serve at Ohio State University) has received the AAAS Socio-Psychological Prize for his paper on bias in experimenters. This $1000 award, offered through the generosity of an anonymous donor, is given for a meritorious essay that furthers comprehension of the psychological-social-cultural behavior of human beings through studies based on explicitly stated assumptions or postulates which lead to experimentally verifiable conclusions or deductions.

Rosenthal's prize-winning work, which describes a series of three experiments, is devoted to the thesis that the personality and expectations of experimenters influence the results they obtain. Rosenthal points out that although this personal element in social science research has long been known, it has received little attention. He plans to continue his investigations in the area, having already scheduled 3 years of additional research.

Rosenthal earned all of his degrees from the University of California at Los Angeles; he received his Ph.D. in 1956 at the age of 23. Before joining North Dakota as an assistant professor, in 1957, he had taught at UCLA and the University of Southern California and had served as a clinical psychologist at the U.S. Veterans Administration Hospital in Los Angeles.

He is a specialist in projective techniques. His work has been supported by the National Institute of Mental Health, and he has a grant for his current research from North Dakota's Faculty Research Grants Fund.

Weisskopf To Head CERN: Reorganization Announced

Eminent Austro-American physicist Victor Weisskopf of Massachusetts Institute of Technology was appointed fourth director-general of the European Organization for Nuclear Research (CERN) at the 18th Session of the CERN Council, held at CERN, in Meyrin, Switzerland, on 8 December. He will serve for 2 years, from 1 August 1961, when he succeeds J. B. Adams, who will return to the United Kingdom as director of the Culham Laboratory for Plasma Physics Research.

Weisskopf was recently granted a leave of absence from M.I.T. to take an appointment as scientific member of the directorate then being set up to assist in CERN management. The directorate consists of two research members, one administration member, and one member in charge of applied physics. The appointment is particularly noteworthy because the United States is not a member of CERN.

New Internal Organization

The CERN Council also announced that, effective 1 January, the organization will have 12 divisions instead of six. A spokesman said, "The decision was reached in order to take into account the fact that CERN has passed from the stage of construction to that of actual fundamental research."

The 12 divisions will have charge, respectively, of the proton synchrotron machine—that is, the 28,000-Mev proton accelerator; the synchrocyclotron machine, a 600-Mev accelerator in operation since 1957; nuclear physics experimentation; engineering; data handling; theory; track chambers, such as cloud chambers and hydrogen-filled bubble chambers; nuclear physics apparatus, such as a propane bubble-chamber and beam-transport equipment; accelerator research—for example, the design of new types of accelerators; site and buildings establishment and maintenance; finance; and general administration.

Spain Joins; New Council Officers

The CERN Council, the organization's governing body, made up of scientific and political representatives of the member states, made another significant announcement. On 1 January Spain will become the 14th member state.

New CERN officers and committee chairmen have been named. Jan Willems (Belgium) is president for 1961. He succeeds François de Rose (France), who has been president for 3 years and whose term of office could not be renewed under the terms of the convention. Edoardo Amaldi (Italy) and Jan Hendrick Bannier (Netherlands) are vice-presidents.

The chairman of the Scientific Policy Committee will be Cecil Powell (United Kingdom), who succeeds Amaldi. W. H. Alexander Hocker (Federal Republic of Germany) will succeed J. H. Bannier as chairman of the Finance Committee.

Flemming Approves New Policy on International Meetings

Arthur S. Flemming, Secretary of the Department of Health, Education, and Welfare, who has been one of the advocates of a change in the State Department policy that limited the attendance of federally employed scientists at international meetings, made the following statement to a staff reporter about the recent easing of the restrictions (see page 1911):

"I am very pleased that the State Department has agreed—barring un-

foreseen international developments—to our government scientists' joining other American scientists in attendance at the Fifth International Congress of Biochemistry in Moscow next August.

Through this joint participation in the Congress we will have an opportunity to display our leadership in biomedical research. Our prestige will be enhanced in an important segment of the world scientific community and we will gain invaluable first-hand information on progress in other countries in the field of biochemistry."

Plans for First British Satellite Announced Jointly by U.K. and NASA

Scientists from Great Britain and the National Aeronautics and Space Administration have recently completed a series of meetings on the cooperative launching of the first British satellite. The experiments to be conducted were selected, and it was agreed that they would be flown in a Scout vehicle to be launched by NASA in about a year. In addition, a second U.K. Scout satellite is being planned.

These joint projects are an outgrowth of the offer made by NASA to provide launching facilities for experiments of mutual interest prepared by scientists of other countries. This offer was made through the U.S. National Academy of Sciences' delegate to COSPAR last year.

Description of Satellite

The initial British satellite, designated International Ionosphere Satellite S-51 but referred to as U.K. No. 1, is to be roughly spherical and nearly 2 feet in diameter. Four telemetry antennas will transmit in the 136 to 137 megacycle-per-second band to ground stations, either directly from the instrument payload or from a tape recorder on which data gathered while the satellite is in orbit will be stored. This tape recorder will play back on command from ground stations, one of which will be in the United Kingdom at the Radio Research Station, Slough. The experimental data will be available first to the U.K. scientists responsible for the instruments in the satellite.

Electrical power will be generated by four paddles carrying solar cells and will be used to charge a system of batteries in the satellite. This power supply will be designed to operate for a year, after which time the radio transmitters will be switched off.

Structure, telemetry system, tape recorder, and power supplies are the responsibility of NASA.

The scientific instruments are being designed and made in Britain. They will include instrumentation for a Birmingham University electron density experiment, which will be carried, in part, on a boom which will swing out radially from the satellite after launching. A similar boom will carry a probe electrode for one of the University College, London, experiments. The cosmic-ray detector of Imperial College, London, will be mounted on the spin axis of the satellite, immediately behind the spherical detector of the University College ion-mass spectrometer.

The satellite will be launched from Wallops Island, Va., into an orbit which will carry it over the United Kingdom. It will be stabilized by spinning about its axis.

Scientists in the News

The American Academy of Arts and Sciences has announced the winners of the Academy Monograph Prizes for 1960. Three awards of $1000 each go to the authors of especially meritorious unpublished monographs, one each in the fields of the humanities, the social sciences, and the physical and biological sciences.

Rodney Needham of Oxford, England, received the social sciences award for a manuscript on "Structure and Sentiment."

Max Jammer of Jerusalem, Israel, won the physical and biological sciences prize for his work entitled "Concepts of Mass in Classical and Modern Physics."

The Academy Monograph Prizes are intended to encourage and assist the publication of scholarly contributions to knowledge that are too long to be published as articles in the learned journals and too specialized or too short for publication as a general book. In response to this prize competition more than 200 manuscripts were submitted by scholars and scientists from all parts of the English-speaking world.

Per K. Frolich, deputy chief chemical officer for scientific activities and chief scientist of the Army Chemical Corps, retired on 31 December. He joined the Corps in 1954 from Merck and Co., Inc., Rahway, N.J., where he was vice president and scientific director of the Chemical Division. Prior to that he had been director of the Esso Laboratories Chemical Division of the Standard Oil Development Company.

While with the Army, Frolich was responsible for research and development and for engineering activities throughout the Chemical Corps. He plans to engage in consulting activities and will continue to live in Annandale, Va.

The third annual F. G. Novy Lecture at the University of Michigan was presented on 15 December by **Herman C. Lichstein**, professor of bacteriology, University of Minnesota. He spoke on "Physiological Control Mechanisms in the Bacterial Cell."

E. Barthel, Jr., assistant director of the Armour Research Foundation at Illinois Institute of Technology, has resigned, effective 1 January, to become program director for international activities of the National Science Foundation, Washington, D.C. He is succeeded by **Niels C. Beck**, who has served as director general of the Union of Burma Applied Research Institute, an ARF project, for the past 4 years.

Dennis C. Smith of the Turner Dental School of the University of Manchester (England) is visiting associate professor at the Northwestern University Dental School for 1960–61. On 18 January he will speak on "Research in Dental Materials and Its Relation to Clinic Practice" as the dental school's annual Thomas L. Gilmer memorial lecturer.

David W. G. Arthur, research associate in the University of Arizona's Steward Observatory and in the lunar and planetary laboratory of the Institute of Atmospheric Physics, has been awarded the British Photogrammetrical Society's Silver Medal for 1960. He received the honor for work done in England in 1958 as cartographer and photogrammetrist with the Ordnance Survey of Great Britain, a post he held for some 15 years. Arthur joined the Arizona staff last October as a member of Gerard P. Kuiper's lunar research group. Kuiper is establishing the IAP's new lunar and planetary laboratory at the university.

Erratum: In the report "Estimate of the human load of mutations from heterogeneous consanguineous samples," by N. Freire-Maia and A. Freire-Maia [*Science* **132**, 1317 (4 Nov. 1960)], recalculation, by the formula of Morton Crow and Muller, leads to values of −0.18 for Caucasians and 8.74 for Negroes, instead of the values of −0.24 and 10.46, respectively, given at the end of the next-to-last paragraph.

Reports

International Geophysical Calendar for 1961

Abstract. Coordination of certain types of geophysical observations and analyses throughout the world is accomplished by the advance selection of days and intervals for such work. A committee under the International Council of Scientific Unions has issued the calendar for 1961, together with a brief explanation and examples of how it may be used in planning geophysical programs.

The International Geophysical Calendar 1961 (Fig. 1) (*1*) designates some special days and intervals for special attention for geophysical experiments and analysis. The calendar serves to encourage world-wide coordination of observation or analysis of those geophysical phenomena which vary significantly during the course of a year. These phenomena are mainly in the scientific disciplines dealing with the earth's atmosphere. In some experiments, such as the routine measuring of variations of the earth's magnetic field, the observing and analysis programs at observatories are carried out at a uniform level throughout the year; in these cases the calendar is not needed. However, in many other experiments (for example, rocket experiments) it is not practical or meaningful to carry out the same program every day. Here the calendar can provide a useful mechanism for coordination. Experimenters will know that their colleagues in other laboratories and in other disciplines will tend also to carry out experiments on the days or during the intervals marked on the calendar. In this way, results of experiments may be more easily and usefully compared.

In some scientific fields, international scientific organizations have made specific recommendations for programs to be carried out on days or during intervals marked on the calendar. In others, the arrangements are informal or self-evident. Some examples are given below, along with the criteria for selection of dates.

Regular World Days are three consecutive days each month. They always come in the middle or just after the middle of the month, and they include, where possible, the times of equinox and solstice. They come in the middle of the week—Tuesday, Wednesday, and and Thursday. The groups of Regular World Days are evenly spaced through the year so far as this is practical. They include, wherever possible, days of solar eclipse and meteor showers. One Regular World Day each month (always Wednesday) is designated the day of highest priority.

The Regular World Days are intended for experiments or for observational or analysis programs which, as a practical matter, can be carried out only about 10 percent of the time and should be spaced through the year. Further, it is suggested that whenever there are no special reasons for selecting some other days, the Regular World Days be used for unusual or special experiments. This applies perhaps particularly to fields in atmospheric geophysics, including aspects of cosmic rays, meteorology, airglow, ionosphere, geomagnetism, and aeronomy. Examples of such special experimentation in ionospheric physics are oblique incidence pulse transmission and reception; absorption measurements by pulse reflection technique; extended observations of "whistlers" and very low frequency emissions; accelerated vertical sounding observations; detailed reduction of vertical sounding ionograms by *f*-plot, *h'*-plot, and so on; and hourly reduction from ionograms of *F*-region true height parameters *hc* and *qc*.

The Regular World Days with highest priority are to be used for work which can be undertaken on only one day each month. All of the foregoing examples apply if the rate of three days per month is unnecessary or proves to be too heavy. A specific example is the recommended program for 1959 and subsequent years of exchange of copies of original ionograms in ionospheric vertical sounding work, made by the International Scientific Radio Union –IGY (URSI–AGI) Committee. This recommends that ionograms for the Regular World Day of highest priority each month (and also for one disturbed period each year) be sent to World Data Centers for interchange.

Reguar World Intervals are ten consecutive days in each quarter year, selected to include the three Regular World Days of the month and also the times of the equinox or solstice. If possible they include days of solar eclipse and meteor showers. Weekends and holidays that are widely observed have, whenever possible, been avoided.

The Regular World Intervals are intended as periods for experiments which for practical reasons cannot be carried on continuously but for which statistics on seasonal variations are especially needed. Ionospheric drift and high-atmosphere wind measurements are two examples. Schedules for interchange of sample detailed data in several disciplines have made use of the Regular World Intervals. In some network observational programs, both the Regular World Intervals and the Regular World Days are used, in order to determine the variations throughout the year but with improved statistics at the equinoxes and solstices.

World Meteorological Intervals are also ten consecutive days each quarter year, but displaced by one month from the equinoxes and solstices. They are intended to cover the times of marked seasonal change in certain meteorological phenomena which tend to come about a month after the equinoxes and solstices. They have been chosen, through World Meteorological Organization (WMO) and Committee on Space Research (COSPAR) channels as 16–25 January, April, July, and October, respectively; the January and October intervals have been designated by COSPAR as the more important ones.

The World Meteorological Intervals now are primarily periods for carrying out synoptic meteorological rocket programs, with stations obtaining atmospheric profiles up to 50 kilometers or more at least once daily during the 10-day intervals. The intervals have also been used during and since the IGY for balloon-sounding programs involving either special instruments or launchings to unusually high altitudes for balloons.

International Rocket Weeks chosen for 1961 by COSPAR are 12–18 February and 16–22 July. The first of these includes the time of the total solar eclipse of 15 February and is intended for study of solar effects. The second

---

Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper.

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

was selected for study of summer atmospheric structure (Northern Hemisphere).

The International Rocket Weeks provide two periods during the year when rocket studies of the atmosphere and of the sun will be on as nearly a synoptic basis as is possible at this stage of the science and technology (*2*).

The 1961 calendar marks the days of solar eclipse—15 February (total) and 11 August (annular). Some special programs may be expected to be carried out in appropriate parts of the world to study effects of the eclipses on the earth's atmosphere. It is especially important that the record of solar activity during and near the times of eclipse be as full as possible. Many solar-activity observatories issue specially detailed reports of their observations on days of eclipse to assist in the interpretation of the geophysical efforts. Ionospheric stations customarily increase their observing programs on such days, even if the magnitude of eclipse at their location is small.

Also shown on the 1961 calendar are days when meteor shower activity is unusually high. Geophysicists using meteor techniques often intensify their observing programs on these days. Attention is also called to these days because ionization produced by meteors may account for unusual effects in other geophysical experiments.

The International Geophysical Calendar marks only those dates which can be selected long in advance, either by general agreement or, in the case of eclipses and meteor showers, by reliable long-term prediction. Periods of great magnetic, auroral, and ionospheric disturbance are also of great geophysical interest, and world-wide coordination of observation is clearly desirable. This is also accomplished under the auspices of the International World Day Service (in close collaboration with the URSI Central Committee on URSIgrams), in the program for the immediate designation of Geophysical Alerts and for selection, on a current basis, of Special World Intervals. Arrangements for receipt of such information by telegram or radio broadcast can be made, as may be practical, with one of the solar-geophysical Regional Warning Centers, whose telegraphic addresses are as follows: (Western Hemisphere) AGIWARN WASHINGTON (U.S.A.); (Western Pacific) AGI KOKUBUNJI (Japan); (Eurasia) NIZMIR MOSCOW (U.S.S.R.); (Western Europe) either IONOSPHARE DARMSTADT (G.F.R.), GENTELABO PARIS (France), or AGI NEDERHORSTENBERG (Netherlands).

The meteorological telecommunications network coordinated by the World Meteorological Organization carries such information once daily, soon after 1600 U.T. A description of the Geophysical Alerts and Special World Intervals plan can be obtained from these centers or from the secretary of the International World Day Service (IWDS). Many geophysical stations increase their programs or carry on special experiments during disturbed periods; the Geophysical Alerts and Special World Intervals program serves to coordinate these activities on a world-wide basis and is especially useful for stations not near the auroral zones, in regions where the beginning of a major disturbance may not be immediately apparent from local observations.

The IWDS, in close collaboration with the URSI Central Committee on URSIgrams, also fosters arrangements for prompt notification of major solar flare events which have important and sometimes long-lasting geophysical effects. These notifications are also made through the Regional Warning Centers.

A summary record of significant solar and geophysical events is being prepared as a "Calendar Record" for the IGY period and also for 1959. This work is now under IWDS auspices. If these volumes prove to serve a useful purpose, similar calendar records may be compiled for 1960 and 1961.

The International World Day Service was established in 1958 by the International Council of Scientific Unions (ICSU) and is administered by the International Scientific Radio Union, 7 Place Emile Danco, Brussels 18, Belgium. The IWDS Steering Committee consists of A. H. Shapley (URSI), M. Nicolet

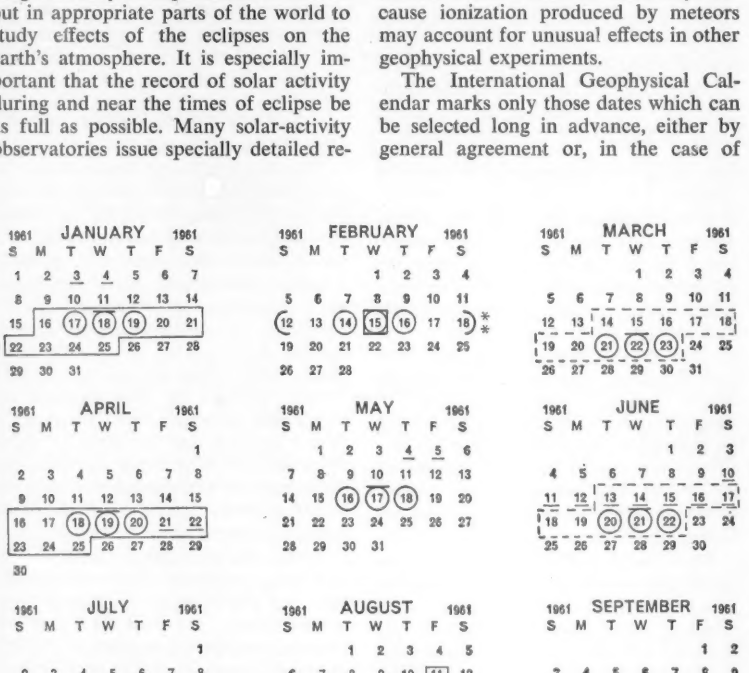

1961 JANUARY 1961
1961 FEBRUARY 1961
1961 MARCH 1961
1961 APRIL 1961
1961 MAY 1961
1961 JUNE 1961
1961 JULY 1961
1961 AUGUST 1961
1961 SEPTEMBER 1961
1961 OCTOBER 1961
1961 NOVEMBER 1961
1961 DECEMBER 1961
1962 JANUARY 1962
(17) Regular World Day (RWD)
(18) RWD with highest priority
21 Day with unusual meteor shower activity
15 Day of solar eclipse
16 17 18 19... World Meteorological Interval (WMI)
14 15 16 17... Regular World Interval (RWI)
12 13 14 15... International Rocket Week (IRW)
Notes : (*) WMI in January and October considered most important
(**) Feb. 15, 1961 : RWD with highest priority

Fig. 1. International Geophysical Calendar 1961. The calendar was issued November 1960 by the International World Day Service under the auspices of the International Scientific Radio Union.

[International Union of Geodesy and Geophysics (IUGG)], and J. F. Denisse [International Astronomical Union IAU)], with R. Coutrez (URSI) as secretary. The IWDS obtains nominal support from the ICSU Federation of Astronomical and Geophysical Services. Shapley serves as spokesman for IWDS and as its correspondent to other ICSU groups such as the International Committee on Geophysics (CIG) and the Committee on Space Research (COSPAR).

The International Geophysical Calendar for 1961 was drawn up by Shapley and J. V. Lincoln in consultation with URSI, IUGG, and IAU, both directly and through CIG and COSPAR. Recommendations also have come from representatives of WMO and from interested individual scientists. A similar calendar was issued for 1960 along the lines of the calendars for the IGY and International Geophysical Cooperation 1959, issued under the auspices of the ICSU Special Committee for the International Geophysical Year and described in the "IGY Instruction Manual for World Days and Communications" (*3*).

A. H. SHAPLEY
Boulder Laboratories, National Bureau of Standards, Boulder, Colorado

References and Notes

1. Copies of the calendar are available upon request to the Secretary General, International Scientific Radio Union, 7 Place Emile Danco, Brussels 18, Belgium.
2. More detailed recommendations by working group 2 of the Committee on Space Research (J. Bartels, chairman) appear in the *COSPAR Information Bulletin*.
3. *IGY Annals* (Pergamon, New York, 1959), vol. 7.

25 November 1960

Suppressive Effects of 2-Thiouracil on Differentiation and Flowering in Cannabis sativa

Abstract. The pyrimidine, 2-thiouracil, partly annuls the effect of photoperiodic induction in the short-day plant, *Cannabis sativa* L., when it is supplied at the onset of the dark period in quantities of 15–30 μg per plant. This treatment also produces aberrations in cellular differentiation in the leaves. Tracer studies show that 2-thiouracil becomes bound in cellular ribonucleic acid, which suggests that the effects on morphogenesis are due to interference with nucleic acid metabolism.

2-Thiouracil is highly effective in suppressing or retarding certain processes of development and differentiation in the short-day plant *Cannabis sativa* (hemp) in concentrations which do not immediately inhibit normal cell extension growth. In the experiments in which these effects have been observed, hemp plants were grown in growth rooms in light at 900 to 1000 ft-ca, with air temperature regulated at 22°C and relative humidity at 70 percent. The plants were kept in a vegetative condition in a daylength of 18 hours to ages of 3 to 4 weeks, after which photoperiodic induction was given by transfer to a daylength of 8 hours. The 2-thiouracil was supplied by painting standard areas of the upper epidermis of the youngest fully expanded leaves with an aqueous solution containing 100 μg/ml, the area being adjusted to establish the required dosage. Traces of detergent ("Teepol") were added to aid wetting.

In hemp, a dioecious species, exposure to seven or more short days at an age of 3 weeks induces the formation of fertile flowers at several successive nodes of the main stem in both sexes (*1*). Daily dosages of 2-thiouracil in the range of 15 to 30 μg per plant, supplied just before the onset of the dark period, severely reduced the flowering response of male plants to an induction period of 10 short days, and almost abolished the response of female plants. In one experiment, short-day induction began at an age of 25 days with batches of eight plants, the first 2-thiouracil treatment being given just before transfer to the first dark period. In the control plants of genetically male sex, the first fertile flowers were differentiated uniformly at the sixth node of the main stem; in male plants receiving 2-thiouracil, the first distinguishable buds appeared at node 8, but these were always without anthers. Among the female plants, the mean node number for the first fertile flowers in the controls was 7; of the plants of this sex receiving 2-thiouracil, only one formed a distinguishable bud during the 4 weeks following induction, and this, at the ninth node, was without gynoecium.

In this experiment plants of both sexes showed some retardation in general development as a result of treatment during photoperiodic induction. Although in part the reduction in flowering response may be attributable to this, it seems likely that the effect is more specific since there was little flowering during the recovery period, and the plants ultimately resumed vegetative growth. This suggests a partial blocking of the developmental processes involved in flowering, and it is significant that in some of these experiments it was accompanied by histological aberrations suggesting a parallel effect on cellular differentiation. Thus, with daily dosages of 10 to 30 μg of 2-thiouracil, striking modifications of leaf structure were initiated. During protracted periods of treatment, abnormalities became progressively more severe from node to node, leaves showing first a reduction of pigmentation attributable to a diminution of chloroplast population, then modifications in mesophyll structure, then a failure of the lamina to expand normally, accompanied by abnormalities in epidermal features such as stomata, and finally aberrations in vasculation.

This increasing severity of symptoms from node to node indicates a relationship with the age of leaf primordia, and the readiest interpretation of the sequence of effects is that it represents in inverse order that order in which the processes of cellular differentiation normally do occur in the leaf. The remarkable extent to which mesophyll differentiation is affected can be seen in Fig. 1, in which sections of the lamina of a normal leaf and that of one developed in the presence of 2-thiouracil two nodes above that of treatment are compared. In the modified leaf, while cellular growth has hardly been impaired, extension has been practically isodiametric in the cells of all layers, so that at their final volume the cells differ greatly in shape from their homologues in the normal leaf.

The fate of 2-C^{14}-2-thiouracil introduced through the leaf was followed autoradiographically. In one experiment, three doses were given at daily intervals. The upper leaves were then removed from one sample of plants to observe the immediate fate of the tracer, while another sample was permitted to grow on for 3 weeks to determine the final distribution. From autoradiographs prepared in the usual manner on Ilford x-ray film, it was found that the labeled 2-thiouracil became rapidly distributed in all growing tissues above the level of application, the accumulation in young leaf primordia being especially marked. After this early incorporation there was little subsequent redistribution, for the bulk of the tracer remained bound in the tissues which were actively growing at the time of treatment.

The chemical distribution of the bound 2-C^{14}-2-thiouracil was examined to determine what proportion could be associated with ribonucleic acid. The leaves were killed and thoroughly extracted with boiling 70 percent ethanol, and then defatted in ether. Samples of the alcohol and ether extracts were plated for counting. The leaves were then dried, pulverized, and the thoroughly homogenized powder was divided into two equal portions. One portion was suspended in distilled water, and the other in 0.01 percent ribonuclease (crystalline analytical grade, Biochemica Boehringer), and both samples were incubated overnight at 37°C. The undigested residues were centrifuged, and samples were taken of the supernatants for counting. The

extraction of the remaining nucleic acids was completed with normal perchloric acid at 70°C. Of the total amount of recovered radioactivity, 11 percent was present in the alcohol extract, and a negligible amount in the ether fraction. In the respective samples, ribonuclease digestion released 76 percent, and the water extraction, 32 percent, the balance in each case being located in the perchloric acid extract. This result suggests that the bulk of the radioactivity bound in these leaves was present in the ribonucleic acid fraction.

Various analogues of naturally occurring purines and pyrimidines have recently been shown to have inhibitory effects on development and cellular differentiation in higher plants. Thus 5-fluorouracil partly annuls the effects of short-day induction in *Xanthium pennsylvanicum* (*2*), and 2-thiouracil similarly blocks flowering in *Streptocarpus wendlandii* (*3*). A remarkable case of the blockage of a developmental step on a cellular level has been reported for *Dryopteris erythrosa* (*4*), in which the transition from one- to two-dimensional growth in the gametophyte is blocked by 8-azaguanine. In all these cases, the implication is that the analogue functions by interfering with nucleic acid metabolism.

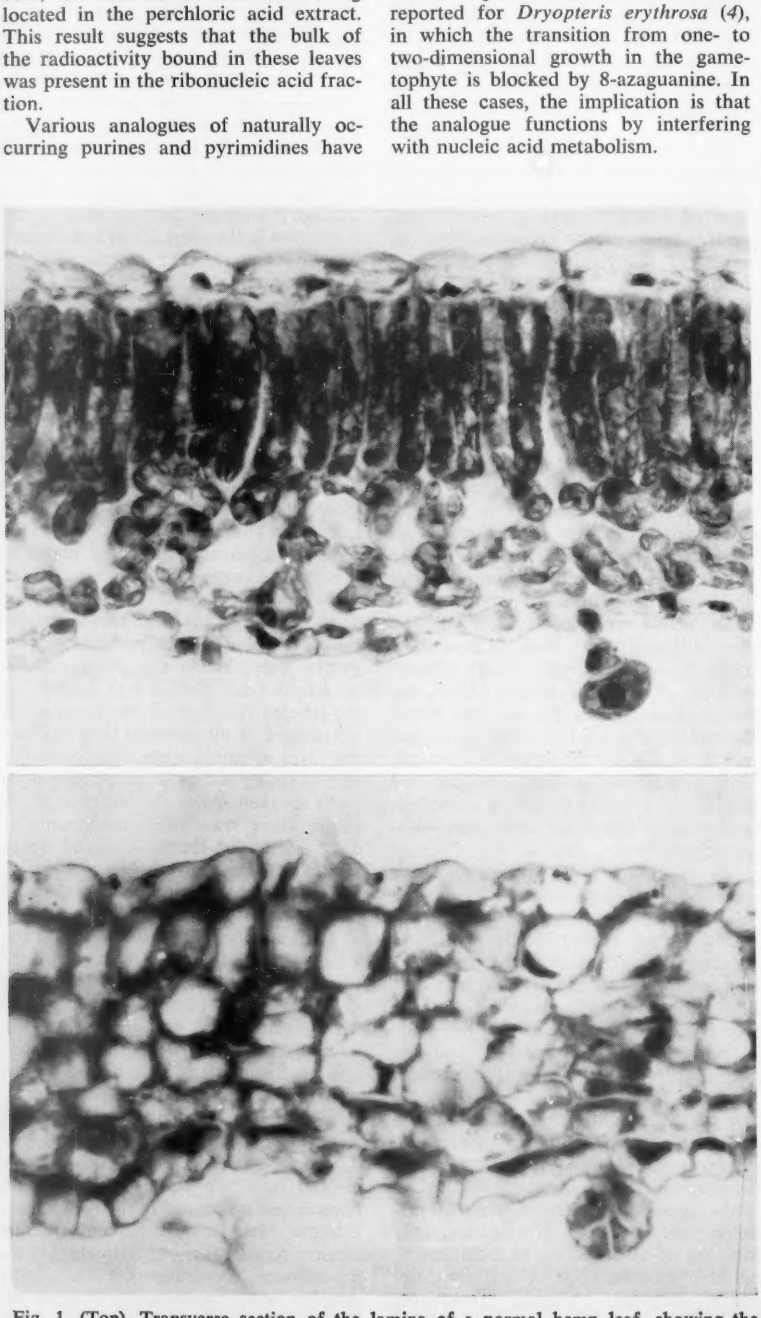


Fig. 1. (Top), Transverse section of the lamina of a normal hemp leaf, showing the characteristic differentiation of the mesophyll tissues. (Bottom), Section of a leaf of hemp developed in the presence of 2-thiouracil. The lamina is composed of a plate of undifferentiated parenchyma (about × 820).

Salisbury and Bonner (*2*) suggest that, in the inhibition of flowering in *Xanthium*, 5-fluorouracil affects the synthesis or effectiveness of the products of the inductive dark period. However, it seems to me that the response is more likely to be due to a loss of capacity of apical meristematic tissues to react to leaf-generated stimuli. Viewed in terms of gene action, it may well be that the loci, quiescent during vegetative growth, which are activated following photoperiodic induction, are unable to produce their characteristic proteins in the presence of factors modifying intermediate stages of ribonucleic acid synthesis, so that the new developmental pathway, namely flowering, cannot be entered. The concomitant effects of 2-thiouracil on cellular differentiation described above could be taken to support such a hypothesis (*5*).

J. HESLOP-HARRISON
Department of Botany, University of Birmingham, Birmingham, England

References and Notes

1. J. Heslop-Harrison and Y. Heslop-Harrison, *Proc. Roy. Irish Acad. B* **59**, 257 (1958).
2. F. B. Salisbury and J. Bonner, *Plant Physiol.* **35**, 173 (1960).
3. D. Hess, *Planta* **54**, 74 (1959).
4. Y. Hotta and S. Osawa, *Expil. Cell Research* **15**, 85 (1957).
5. A full account of this work will be given elsewhere. The experiments were performed with the facilities of the Queen's University, Belfast, to which institution I tender my thanks.

15 August 1960

Learned Behavior of Rhesus Monkeys following Neonatal Bilateral Prefrontal Lobotomy

Abstract. Bilateral ablation of dorsolateral frontal cortex in the newborn animal failed to produce the frontal lobe syndrome typical of the adolescent and adult stages. The crucial tests (delayed response, string tests, and discrimination learning) were performed 3 to 4 months postoperatively. At this time, no significant differences between normal animals and animals with prefrontal lesions were found.

The classical work of Jacobsen (*1*) demonstrated that adolescent and adult rhesus monkeys with bilateral lesions in the prefrontal areas show a severe deficit on the delayed-response problem and no appreciable loss in discrimination learning. This finding has been confirmed by many independent investigators, including Harlow *et al.* (*2*) and Pribram *et al.* (*3*). Furthermore, research workers in the area agree that there is no spontaneous remission of this syndrome with time. Recent researches reported by Harlow (*4*) demonstrate that the solution of delayed response by monkeys is a function of age and that this capability appears at about 125 days. The purpose of the study re-

ported here was to determine the effect of bilateral prefrontal lesions produced at an early age on learning performance, especially delayed response.

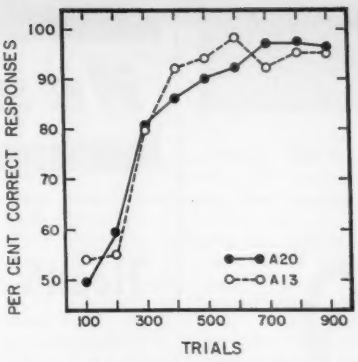
Two 5-day-old rhesus monkeys, Nos. A-13 and A-20, were subjected to bilateral ablation of the dorsolateral prefrontal areas, with complete aspiration of the cortex of the sulcus principalis. Areas 6 and 8 were spared, so that the lesions would be identical to those in the study of French (*5*). The surgery was performed under general anesthesia, from a mixture of ether and oxygen. These animals were then adapted to the Wisconsin general test apparatus, and formal testing began at 132 and 164 days of age for A-20 and A-13, respectively.

The test battery replicated the early learning tests described by Harlow (*4*) and consisted of a single discrimination problem run at the rate of 25 trials a day for 20 days, a battery of delayed-response problems (0- and 5-second delay intervals) presented at the rate of ten trials per day on each problem for 90 days, and a series of two patterned-strings tests, each of which was presented at the rate of 20 trials per day for 20 days. The parallel pattern was presented first for 20 days and was followed by presentation of the two-crossing-strings pattern for the same length of time. All three types of problems of this basic battery of tests were run concurrently until completion. After the basic delayed-response testing, the subjects were given 60 days' additional testing on a battery of delayed response tests (5-, 10-, 20-, and 40-second delay intervals) at a rate of eight trials per day for each delay interval. Upon completion of the single discrimination problem the monkeys were trained on a discrimination learning set, with a series of 600 discrimination problems, each six trials in length, presented at the rate of four problems per day.

On the discrimination problems the two monkeys attained the criterion of ten successive correct responses after zero errors and one error, respectively. These scores are superior to those of 15 normal control monkeys of comparable age, which averaged seven errors, and the scores doubtless reflect chance preferences for the correct stimulus. Discrimination learning loss, of course, was not expected.

Subjects A-13 and A-20 made 88 percent and 95 percent correct responses during the first 100 trials on the parallel-strings test and solved the two-crossing-strings pattern after 452 and 421 trials, respectively. These scores are all well within the "normal" range, as expected.

As is shown in Fig. 1, delayed-response learning was efficient and rapid, and a level of 90 percent correct responses was attained within 500 trials.



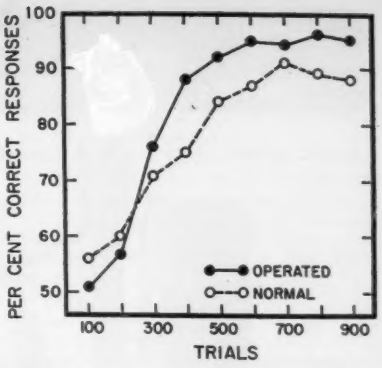
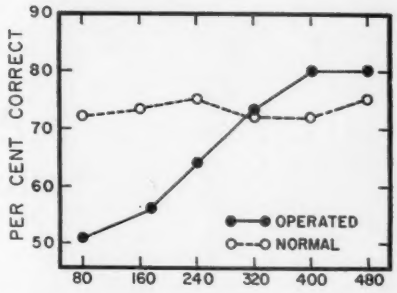


Fig. 1 (left). Individual performance curves on 5-second delayed response. Fig. 2 (right). Comparison of the performance of experimental and normal monkeys of the same age on 5-second delayed response.



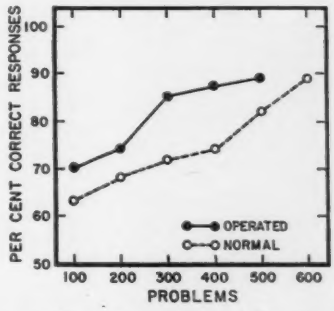


Fig. 3 (left). Comparison of the performance of experimental and normal monkeys of the same age on 40-second delayed response. Fig. 4 (right). Comparison of the performance of experimental and normal monkeys on trials Nos. 2 through 6 of a series of 600 discrimination problems.

If one compares these data with those for 15 normal monkeys tested at equivalent ages (Fig. 2), it may be seen that the performances of the two groups do not differ significantly. Actually, in absolute terms, the scores of the monkeys with prefrontal lesions were slightly superior on the subsequent delayed-response test battery, as illustrated in Fig. 3, for the 40-second delay interval. The test animals were inferior in terms of their early performance but not in terms of their terminal performance. These data may indicate some residual decrement not disclosed in the basic test battery. However, the important finding is the normal or near-normal delayed-response performance of these monkeys with neonatally induced lesions.

The performance of the experimental monkeys and of 15 control subjects on discrimination learning sets is given in Fig. 4. Although the experimental monkeys are superior to the mean of the controls, their scores do not lie outside the normal range. Loss of learning-set ability was not predicted.

The primary importance of this research is the demonstration of a degree of sparing, beyond that predicted, of delayed-response capability following neonatally induced bilateral prefrontal lesions. Indeed, there is no definitive evidence that any learning deficit resulted. These data on delayed response and other intellectual sparing are in keeping with recovery of motor functions, as previously demonstrated by Kennard (*6*), and sparing of somatic sensory functions, as reported by Benjamin and Thompson (*7*).

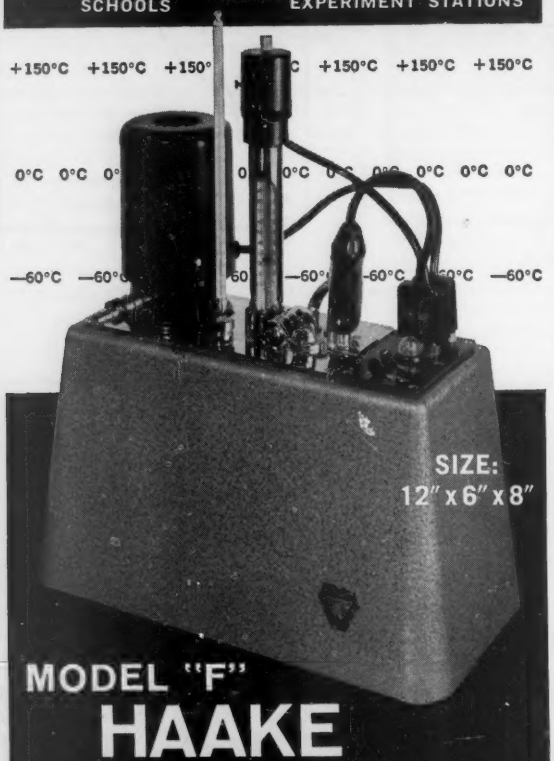
K. AKERT
Department of Anatomy, University of Wisconsin, Madison
O. S. ORTH
Department of Anesthesiology, University of Wisconsin
H. F. HARLOW
K. A. SCHILTZ
Department of Psychology, University of Wisconsin

References

1. C. F. Jacobsen, *Comp. Psychol. Monogr.* **13**, 1 (1936).
2. H. F. Harlow, R. T. Davis, P. H. Settlage, D. R. Meyer, *J. Comp. and Physiol. Psychol.* **45**, 419 (1952).
3. K. H. Pribram, M. Mishkin, H. E. Rosvold, S. J. Kaplan, *ibid.* 565 (1952).
4. H. F. Harlow, *Am. Scientist* **47**, 459 (1959).
5. G. M. French, *J. Comp. and Physiol. Psychol.* **52**, 18 (1959).
6. M. A. Kennard, *J. Neurophysiol.* **1**, 477 (1938).
7. R. M. Benjamin and R. F. Thompson, *Exptl. Neurol.* **1**, 305 (1959).

8 August 1960

FACTORIES
HOSPITALS
LABORATORIES
SCHOOLS
EXPERIMENT STATIONS



MODEL "F"
HAAKE
constant temperature
ULTRA
THERMOSTAT

The ideal circulating thermostat for today's crowded laboratories is the Haake Model "F". Due to its light weight and compact design it can easily be moved around and occupies a minimum of space. It is ideal for any type of instrumentation or for ambulatory use with clinical appliances which require temperature control. Some typical applications include such liquid jacketed instruments as spectrophotometers, refractometers, viscosimeters and blood pH equipment.

SEND FOR COMPLETE DESCRIPTIVE CATALOG 3

BRINKMANN
BRINKMANN INSTRUMENTS, INC.
115 CUTTER MILL ROAD, GREAT NECK, N. Y.
Offices in: Phila., Cleveland, Houston, Miami.

Needed Now

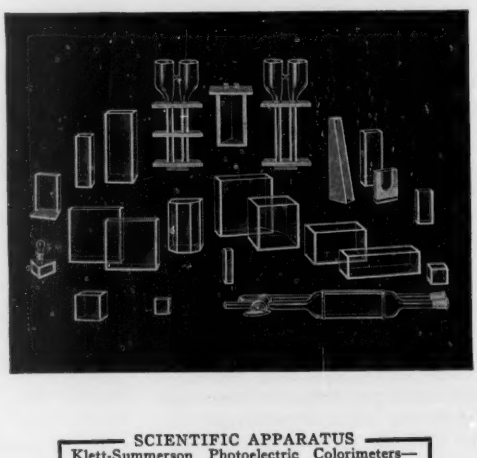
Health Physicist:

To direct and perform health physics and industrial hygiene work at various WTR facilities. Work will also include non-health physics engineering that pertains to reactor and hot lab work. Must have A.B. or B.S. degree and additional training in health physics.

If you qualify for any one of the above positions, write immediately to: Mr. C. S. Southard, Westinghouse Atomic Power Division, P.O. Box 355, Dept. X-60, Pittsburgh 30, Pa.

Westinghouse
ATOMIC POWER DIVISION
FIRST IN ATOMIC POWER

GLASS ABSORPTION CELLS made by KLETT



SCIENTIFIC APPARATUS
Klett-Summerson Photoelectric Colorimeters—Colorimeters — Nephelometers — Fluorimeters—Bio-Colorimeters — Comparators — Glass Standards—Klett Reagents.

Klett Manufacturing Co.
179 East 87 Street, New York, New York

Meetings

Forthcoming Events

January

10–11. Conference on Physics of Polymers, Bristol, England. (Organizing Secretary, Physical Soc., 1 Lowther Gardens, London, S.W.7)

16–18. American Astronautical Soc., annual, Dallas, Tex. (F. F. Martin, AAS, 304 South Woodstock Dr., Haddonfield, N.J.)

16–19. Instrument Soc. of America, winter instrument-automation conf., St. Louis, Mo. (W. H. Kushnick, 313 Sixth Ave., Pittsburgh 22, Pa.)

22–28. Bahamas Serendipity Conf., 3rd, Nassau. (I. M. Wechsler, P.O. Box 1454, Nassau)

23–25. Institute of the Aeronautical Sciences, 29th annual, New York, N.Y. (Meetings Dept., IAS, 2 E. 64 St., New York 21)

23–26. American Meteorological Soc., 41st annual, New York, N.Y. (K. C. Spengler, AMS, 45 Beacon St., Boston 8, Mass.)

24–27. American Mathematical Soc., 67th annual, Washington, D.C. (J. W. Green, Univ. of California, Los Angeles)

24–27. Society for Industrial and Applied Mathematics, Washington, D.C. (G. Kaskey, Remington Rand Univac, 1900 W. Allegheny Ave., Philadelphia, Pa.)

24–27. Society of Plastics Engineers, 17th annual conf., Washington, D.C. (T. A. Bissell, SPE, 65 Prospect St., Stamford, Conn.)

25–27. Mathematical Assoc. of America, annual, Washington, D.C. (H. L. Alder, Dept. of Mathematics, Univ. of California, Davis)

26–27. Western Spectroscopy Conf., 8th annual, Pacific Grove, Calif. (R. C. Hawes, Applied Physics Corp., 2724 S. Peck Rd., Monrovia, Calif.)

27–28. Royal College of Physicians and Surgeons, annual, Ottawa, Ontario, Canada. (T. J. Giles, 150 Metcalfe St., Ottawa)

28–30. Control of the Mind, symp., San Francisco, Calif. (Dept. of Continuing Education in Medicine, Univ. of California Medical Center, San Francisco 22)

28–31. Infertility, sectional meeting, Intern. Fertility Assoc., Acapulco, Mexico. (M. L. Brodny, 4646 Marine Dr., Chicago 40, Ill.)

29–3. American Inst. of Electrical Engineers, winter meeting, New York, N.Y. (E. C. Day, AIEE, Technical Operations Dept., 33 W. 39 St., New York 18)

30–3. Clinical Cong. of Abdominal Surgeons, Miami Beach, Fla. (B. F. Alfano, 663 Main St., Melrose 76, Mass.)

30–4. American Library Assoc., midwinter meeting. (Mrs. F. L. Spain, New York Public Library, 20 W. 53 St., New York, N.Y.)

31–4. American Assoc. of Physic Teachers, New York, N.Y. (F. Verbrugge, 135 Main Engineering, Univ. of Minnesota, Minneapolis)

31–4. American Physical Soc., annual, New York, N.Y. (K. Darrow, APS, Columbia Univ., 116th St. and Broadway, New York)

February

1–3. Solid Propellant Rocket Conf., American Rocket Soc., Salt Lake City, Utah. (R. D. Geckler, Aerojet-General Corp., P.O. Box 1947, Sacramento, Calif.)

1–3. Winter Military Electronics Conv., 2nd, Inst. of Radio Engineers, Los Angeles, Calif. (A. N. Curtiss, IRE Business Office, 1435 S. La Cienega Blvd., Los Angeles 35)

1–4. American Physical Soc., annual, New York, N.Y. (K. K. Darrow, APS, 538 W. 120 St., New York 27)

2–4. Congress on Administration, 4th annual, Chicago, Ill. (R. E. Brown, American College of Hospital Administrators, 840 N. Lake Shore Dr., Chicago 11)

6–8. American Acad. of Allergy, 17th annual, Washington, D.C. (J. O. Kelly, 756 N. Milwaukee St., Milwaukee 2, Wis.)

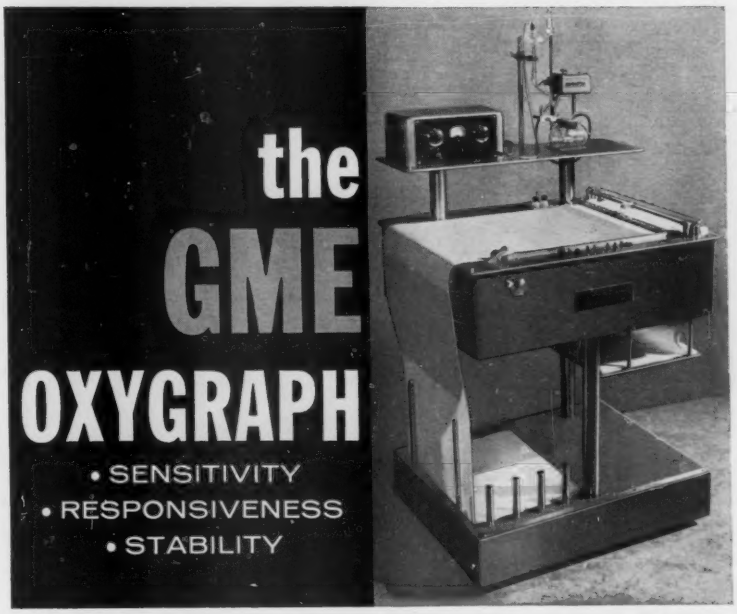
6–8. Geodesy in the Space Age, symp., Ohio State Univ., Columbus. (W. A. Heiskanen, Ohio State Univ., 1314 Kinnear Road, Columbus 12)

6–10. British Medical Assoc., annual, Auckland, New Zealand (E. Grey-Turner, BMA, Tavistock Sq., London, W.C.1)

9–15. Second Allergy Conf., Nassau, Bahamas. (I. M. Wechsler, P.O. Box 1454, Nassau)

13–16. American Soc. of Heating, Refrigerating and Air-Conditioning Engineers, Chicago, Ill. (R. C. Cross, 234 Fifth Ave., New York 1)

(See 16 December issue for comprehensive list)



THE GME OXYGRAPH is a micro platinum cathode oximeter for recording rapid changes of oxygen concentration in solution.

- Unique oscillatory motion provides high sensitivity and stability
- large graph — 40-cm.-wide paper
- 6 speeds — no gear shifting
- Water jacketed cell available

Developed in collaboration with Dr. S. Kuby of the Enzyme Institute, University of Wisconsin, Madison, Wisconsin.

GILSON MEDICAL ELECTRONICS

Middleton, Wisconsin

(On Madison's West Beltline Highway)

New Products

The information reported here is obtained from manufacturers and from other sources considered to be reliable. Neither Science *nor the writer assumes responsibility for the accuracy of the information. All inquiries concerning items listed should be addressed to the manufacturer. Include the department number in your inquiry.*

■ DISPOSABLE MOUSE CAGE, developed at Southern Illinois University, is constructed of transparent plastic said to be inert and nonallergenic and can be autoclaved or incinerated. Autoclaving reduces cage to 1/9 original size. The cages nest so that 100 cages occupy 4 ft^3 of space. Each cage measures 10½ by 8 by 4½ in. (A. S. Aloe, Dept. Sci975, 1831 Olive St., St. Louis 3, Mo.)

■ SPECTROSCOPIC ELECTRODE STAND is fabricated of pure graphite to allow loading and placing of electrodes in a furnace to dry or ignite them with no effect on the stands themselves. Models are available for 1/4- and 3/16-in. electrodes. Each stand holds up to 18 electrodes, spaced to allow room for funnel loading, with each position numbered. (United Carbon Products Co., Dept. Sci970, Bay City, Mich.)

NO GROWING PAINS!

with RSCo *modular gas chromatographs*

You can quickly and easily change to an entirely different system with RSCo modular construction. Insert a detector and power supply for a new detection method, and you'll have the equipment of a whole new system. Add refinements when and where you need them—more sensitive detectors, better regulated power supplies, more stable signal circuits.

Or, for your first investment in gas chromatography, give your laboratory all the advantages of a complete RSCo modular system. Economical conformance to your first needs. Expandability at any time with easily added modules. Progressively greater usefulness because adaptability banishes obsolescence. Highest quality of performance to advance your research projects.

A card or phone call today brings our catalog of nearly thirty top-quality RSCo modules. Whether used in combinations of complete systems or in groups of two or three simply to augment your existing system, the RSCo units do outstanding gas chromatography.

DEPT. A

RSCo **RESEARCH SPECIALTIES CO.**

200 SOUTH GARRARD BLVD. RICHMOND, CALIFORNIA

■ PHOTOELECTRIC RELAY provides an adjustable time delay between changing of light intensity and operation of the relay so that beam interruptions of shorter duration will not cause actuation. Adjustable relay-hold-in time up to 3 sec can also be provided. (Farmer Electric Products Co., Dept. Sci996, 2300 Washington St., Newton Lower Falls, Mass.)

■ OPTICAL PYROMETER measures temperature automatically in the range 1400° to 4500°F or 750° to 2500°C. A portable and a fixed-mounting model are available each with single, double, or triple ranges. Operation is on the two color principle using two narrow-band wavelengths in the visible spectrum. Distance from the target may range from 20 in. to 60 ft. (Instrument Development Labs, Inc., Dept. Sci976, 67 Mechanic St., Attleboro, Mass.)

■ SOIL PULVERIZER, developed at the University of Wisconsin, deaggregates soil samples for analysis to desired and uniform mesh sizes without crushing or powdering individual soil crystals. The device consists of a finned pulverizing head which rotates at adjustable speeds in a mortar. The deaggregated soil is sifted through a screen kept in constant motion. (National Agricultural Supply Co., Dept. Sci973, Fort Atkinson, Wis.)

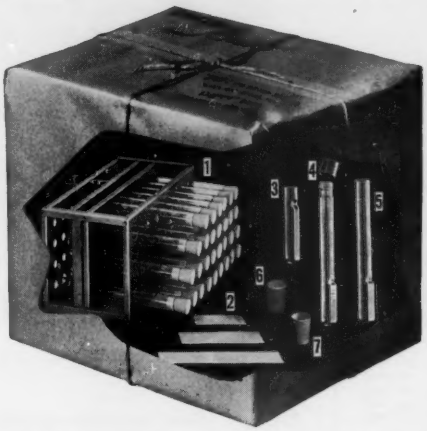
■ FILTER MATERIAL is made of submicron glass fibers impregnated with Teflon. Pore size of 2 to 7 μ remains constant because fibers do not swell. The filter is resistant to heat up to 500°F. Tensile strength is given as 2200 g/in. and is unaffected by wetting. The filter material, 0.002 in. thick, is available in discs and rolls. (Bel-Art Products, Dept. Sci974, Pequannock, N.J.)

■ GAS CHROMATOGRAPH employs a motor-driven transparent film and a photoelectric transmitter and receiver to achieve any combination of time and sequence required in process chromatography. The film is programed by graphite markings spaced to interrupt the photo-electric beam and effect desired sequences such as peak selection, range sensitivity, value actuation, automatic zeroing of the detector cell, and visual readout. Repeatability of the system is said to approach ± 0.1 sec. The programer will accommodate film loop lengths representing analysis times of 4 to 15 min. Adjustment of motor speed provides shorter or longer times. A manual pushbutton overrides the film reader to provide nonautomatic operation. (Mine-Safety Appliances Co., Dept. Sci982, Pittsburgh, Pa.)

JOSHUA STERN

National Bureau of Standards, Washington, D.C.

A PACKAGE UNIT *FOR* *TISSUE CULTURE* TUBE STUDIES!



1. *Self-locking rack*
2. *PRECUT cover slides*
3. *Short type tube*
4. *Screw cap tube*
5. *Rubber stoppered tube*
6. *Rubber stopper*
7. *Silicone rubber stopper*

WRITE FOR COMPLETE DETAILS

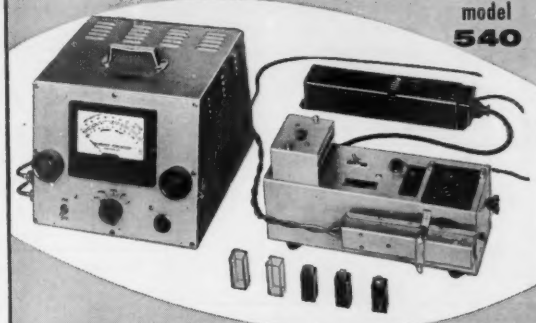
BELLCO GLASS INC.
DEPT. 55 — VINELAND, NEW JERSEY

PHOTOVOLT

LINE-OPERATED MULTIPLIER

FLUORESCENCE METER

model 540



- **High sensitivity . . . full scale for 0.001 microgram quinine sulphate**
- **Micro-fluorimetry . . . liquid volumes down to 1 ml**
- **Low blank readings . . . linear instrument response**
- **High sensitivity nephelometry . . . minute turbidities**
- **Fluorescence evaluation of powders, pastes, and solids; also for spot-tests on filter paper without elution**
- **Selection of filters, interference filters, and sample holders**

Write for Bulletin No. 392 to:

PHOTOVOLT CORP.
95 Madison Avenue • New York 16, N. Y.

Also: pH Meters, Colorimeters, Densitometers

PERSONNEL PLACEMENT

CLASSIFIED: Positions Wanted, 25¢ per word, minimum charge $4. Use of Box Number counts as 10 additional words. Payment in advance is required.

COPY for ads must reach SCIENCE 2 weeks before date of issue (Friday of every week).

DISPLAY: Positions Open. Rates listed below—no charge for Box Number. Rates net. No agency commission. No cash discount. Minimum ad: 1 inch. Ads over 1 inch will be billed to the nearest quarter inch. Frequency rate will apply to only repeat of same ad. No copy changes. Payment in advance is required except where satisfactory credit has been established.

Single insertion	**$40.00 per inch**
4 times in 1 year	**38.00 per inch**

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

Replies to blind ads should be addressed as follows:
Box (give number)
Science
1515 Massachusetts Ave., NW
Washington 5, D.C.

POSITIONS WANTED

(a) **M.D.** University Pennsylvania; qualified chemistry, physiological chemistry, comparative anatomy; 6 years, staff, important pharmaceutical company, including 3 years, medical examiner; seeks administrative level, pharmaceutical industry, clinical investigation; foreign languages: French, German, Spanish, Italian, some Japanese; American born; age 38. (b) **Bacteriologist,** Ph.D. Purdue; considerable public health experience; past 3 years, chief bacteriologist, 350-bed general hospital; seeks similar appointment, warm climate; mid-40's. Science Division, Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash, Chicago. X

POSITIONS WANTED

Female (M.S.), chemical and biological background. Experienced in medical literature searching, abstracting. Desires responsible position. Box 226, SCIENCE. 12/30

Neuropharmacologist, Ph.D., training and experience in neurophysiology. Seeks teaching or research institute position. Box 217, SCIENCE. 12/16, 30; 1/13

(a) **Physiology (Endocrinology)** Ph.D., veterinary medicine B.A.; atomic energy fellowship; experienced in hormone research and physiology teaching; desires academic or research appointment. (b) **Young Biochemist,** Ph.D. June 1961; 1 year of malt research, 1 year of Navy service in animal radiological research; interested in teaching or research position. (Please write for information regarding these and other scientists in all fields; nationwide service.) S12-5 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. BEST SOURCE FOR BEST SCIENTIFIC PERSONNEL

POSITIONS OPEN

Applications are invited for a

Faculty Position in Agriculture or Cereal Chemistry

Duties involve direction of graduate research and teaching cereal and organic chemistry. Rank and salary dependent upon qualifications. Send résumé to Head, Department of Chemistry, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

BACTERIOLOGIST

Opening in chemotherapeutic research in expanding midwestern pharmaceutical firm.
The opening is in bacteriological research. Experience in an industrial laboratory desirable but not required.
Please send résumé and salary requirement to:
Box 232, SCIENCE

POSITIONS OPEN

BIOLOGICAL SCIENCE

Unusual teaching opportunity in the biological sciences at a small midwestern college. Ph.D. required. Salary $6500–$7500 depending upon qualifications and experience.
Please direct applications to Clarence R. Noe, Executive Dean, Eureka College, Eureka, Illinois. X

(a) **Pathologist**; certification not required to head department, clinical toxicology, prominent eastern pharmaceutical company; duties include evaluation liaison work; about $17,000. (b) **Biochemist**; M.S., Ph.D., to head department, expanded laboratories now supervised by two pathologists; 300-bed general hospital; to $12,000; city 30,000; Mideast. (c) **Pharmacologist**; M.D. as associate medical director; conduct clinical trials, collect data; requires writing, administrative ability; some travel; to $17,000 plus liberal expense accounts; West Coast. (d) **Research Pharmacologist**; two Ph.D.'s for new laboratories, prominent eastern company. (e) **Bacteriologist**; M.S., Ph.D., to supervise reorganized department, 300-bed general hospital; $9000; southeastern resort city 50,000. (f) **Associate Medical Director**; M.D. able to administer program providing clinical papers supporting product line; some travel; technical division, midwestern pharmaceutical company. (g) **Biochemist**; Ph.D. experienced clinical chemistry; supervise section, 300-bed university-affiliated hospital; $10,000; West. (h) **Associate Director Clinical Research**; research-minded M.D., industrial experience preferred; plan, supervise clinical investigation of new drugs; travel required; client pays fee; prominent midwestern company. (i) **Biochemist**; Ph.D. to head department, busy laboratory, approved 250-bed general hospital; $12,000; Southeast. (j) **Director, Clinical Research**; midwestern branch, prominent company; requires M.D. experienced clinical pharmaceutical research; to $12,000. Science Division, Woodward Medical Bureau, Ann Woodward, Director, 185 North Wabash Avenue, Chicago. X

POSITIONS OPEN

ARMOUR PHARMACEUTICAL COMPANY

has need of a creative independent investigator to head a project in pharmacological research. Excellent opportunity to investigate with considerable freedom in a relatively unexplored area. Ph.D. Pharmacologists and Physiologists are invited to apply. Write E. J. Reidy, Personnel Manager, Box 511, Kankakee, Illinois.

BIOLOGICAL SCIENTIST

Large Philadelphia pharmaceutical firm has challenging opening for scientist in evaluation of laboratory and clinical studies of new drugs. Applicants should be biochemistry and/or physiology graduates with master's degree or similar background or training. Outstanding benefit program includes tuition assistance. Please submit complete résumé to L. H. Watson, Smith Kline & French Laboratories, 1540 Spring Garden St., Philadelphia 1, Pa.

BIOLOGIST

M.S. or equivalent. Dynamic eastern pharmaceutical company seeks young scientist with sound training in virology and tissue cell culture or related fields, to participate in newly organized project in chemotherapy of virus diseases. Send résumé and references to

Box 225, SCIENCE

BIOPHYSICISTS & BIOCHEMISTS—

Basic research institute (East Coast) with several programs in the physical sciences desires to intensify and expand the biosciences group. Current program includes photochemistry, photosynthesis and related aspects of physical and chemical biology. Positions and salaries commensurate with training and experience. Postdoctoral fellowships also available. Send résumé and salary requirements to: Box 224, Science, 1515 Mass. Ave., NW, Washington 5, D.C.

Chief of Pediatrics for internationally known chest hospital. Pediatric service now 50 beds, to be expanded to approximately 125 beds. Includes tuberculosis, cardiac disease amenable to surgical intervention, asthma, cystic fibrosis, and other chest entities. Active research, teaching, and rehabilitation programs. Mail curriculum vitae to Dr. S. Dressler, Chief of Staff, National Jewish Hospital, 3800 East Colfax Avenue, Denver, Colorado. 1/6, 13, 20

(a) **Protozoologist** for insect disease research at agriculture institute: foreign. (b) **Neurophysiology Assistant Professor** for medical school; ample research opportunities; $8000–$10,000; South. (c) **Pharmacologist** for new research laboratories of expanding firm; East. (d) **Medicinal Chemistry Research Director** to plan program and supervise senior chemists for leading drug firm; advancement opportunities; $15,000–$20,000; East. (e) **Biochemist** to head section in large hospital, teach, and conduct research; around $9500; Pacific Northwest. (f) **Bacteriologist** for active hospital; $9000; Southeast. (g) **Embryology Assistant Professor** to organize and teach course to science and medical students at leading university; foreign; (h) **Chemists** with radioisotope training for nuclear science research firm; around $10,000; East. (i) **Biology Associate or Assistant Professor** interested in cytology, virology, or animal physiology for teaching and research at university; East. (Please write for details; also many other positions available through our nationwide service.) S12-5 Medical Bureau, Inc., Science Division, Burneice Larson, Chairman, 900 North Michigan Avenue, Chicago. **BEST SOURCE FOR BEST MEDICAL-SCIENTIFIC POSITIONS.**

FELLOWSHIPS

TEACHING ASSISTANTSHIPS

for Ph.D. candidates beginning 1 September. Annual stipends up to $3200. Research in red blood cell chemistry, enzyme chemistry, plant biochemistry, protein physical chemistry, lipid metabolism, clinical chemistry. Write to Head, Department of Biochemistry, University of Alberta, Edmonton, Canada. 12/16, 23, 30

The Market Place

BOOKS • SERVICES • SUPPLIES • EQUIPMENT

DISPLAY: Insertions must be at least 1 inch in depth. Weekly invoices will be sent on a charge account basis—provided that satisfactory credit is established.

Single insertion	$40.00 per inch
4 times in 1 year	38.00 per inch
7 times in 1 year	36.00 per inch
13 times in 1 year	34.00 per inch
26 times in 1 year	34.00 per inch
52 times in 1 year	32.00 per inch

For PROOFS on display ads, copy must reach SCIENCE 4 weeks before date of issue (Friday of every week).

SUPPLIES AND EQUIPMENT

SWISS MICE

BACTERIOLOGICAL AND GROSS TISSUE STUDY TECHNIQUES USED IN OUR QUALITY CONTROL

HUNTINGDON FARMS, INC.
2548 NORTH 27th ST. PHILA. 32, PA.

YOU NEED THIS **FREE** CATALOG FOR YOUR FILES

Serums, antiserums and bloods of all kinds for technicians and tissue culture laboratories. No salesman will call.

COLORADO SERUM CO.
4950 York St. • MAin 3-5373 • Denver 16, Colo.

"From the hand of the veterinarian to research"®

albino rats

CHARLES RIVER CD
(Caesarean derived)
CHARLES RIVER SD
(Sprague-Dawley descendants)
CHARLES RIVER W
(Wistar descendants)

HYPOPHYSECTOMIZED RATS

- Only Charles River CD animals used
- Rigidly controlled environment (same bldg.) birth to surgery.
- High speed surgery by graduate biologists.
- 10 years experience animal surgery.
- Overnight air service from Boston

THE CHARLES RIVER BREEDING LABS
1018 Beacon St., Brookline 46, Mass. RE. 4-2000
Henry L. Foster, D.V.M., President

SUPPLIES AND EQUIPMENT

®**Mice** CAESAREAN-DERIVED
CHARLES RIVER CD-1
Hypophysectomies

THE CHARLES RIVER MOUSE FARMS
Affiliate, The Charles River Breeding Labs
1018 Beacon St., Brookline 46, Mass. RE 4-2000

Do You Need:

Silicic Acid?

(Specially prepared for lipid chromatography)
ASK FOR PRICE LIST SSA

Do You Need:

Analytical Grade Ion Exchange Resins?

(Prepared from Dowex Resins)
ASK FOR PRICE LIST SM

Do You Need:

Cellex Cellulose Ion Exchangers?

(For fractionation of proteins, nucleic acids, and enzymes)
ASK FOR PRICE LIST SCX

BIO-RAD *Laboratories*
32nd & GRIFFIN AVE. • RICHMOND, CALIFORNIA

Laboratory Animals

Mice Hamsters Guinea Pigs
Rats Rabbits

Information sent on request
H. S. HURLBURT
Animal Research Center, Bainbridge, N.Y.
WOrth 7-5415

Now taking orders for:

C3H • AKR • STRONG A • C57BL
(C3H x 101) F1

TEXAS INBRED MICE CO.
305 Almeda-Genoa Rd.; R.F.D. 7, Box 1232-C
Houston 21, Texas

BOOKS AND MAGAZINES

SCIENTIFIC JOURNALS WANTED

Sets, Runs and Volumes bought at top prices. Your wants supplied from our Back Files of over 3,000,000 periodicals. Abrahams Magazine Service, N. Y. 3, N. Y.

ASTRONOMY
For Everyone

Enjoy SKY AND TELESCOPE magazine monthly. Profusely illustrated. Observing and telescope making departments, monthly star and planet charts. Subscription in U. S.: $5.00, 1 year; $9.00, 2 years. Sample copy, 50¢.

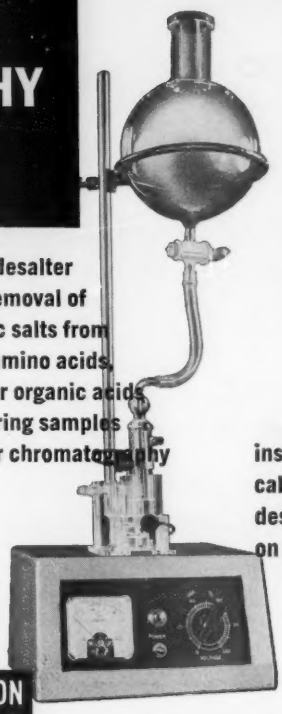
Dept. S
SKY AND TELESCOPE Cambridge 38, Mass.

Your sets and files of scientific journals

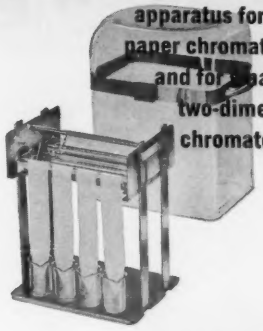
are needed by our library and institutional customers. Please send us lists and description of periodical files you are willing to sell at high market prices. Write Dept. A3S, CANNER'S, Inc. Boston 20, Massachusetts

PAPER CHROMATOGRAPHY APPARATUS

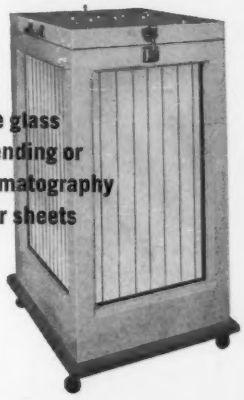
Write for Catalog K-50 Describing Special Apparatus for Paper Chromatography



electric desalter for the removal of inorganic salts from sugars, amino acids, and other organic acids in preparing samples for paper chromatography



apparatus for eluting paper chromatograms and for small scale two-dimensional chromatography



insulated, double glass cabinets for ascending or descending chromatography on paper strips or sheets

KENSINGTON SCIENTIFIC CORPORATION
1717 FIFTH STREET · BERKELEY 10, CALIFORNIA

NEW UNIVERSAL RESEARCH MICROSCOPE FOR FLUORESCENCE

- Instant change-over from mercury arc to tungsten illumination
- Completely enclosed UV beam
- 100% of light toward binocular tube, focusing telescope or camera
- Integrated magnification changer and centering telescope
- Built-in vibration absorbers
- Total cost with planachromats as illustrated about $3000.

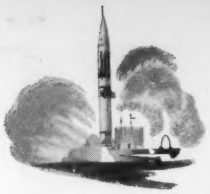
Available for prompt delivery from

Write for Bulletin 470

BRINKMANN

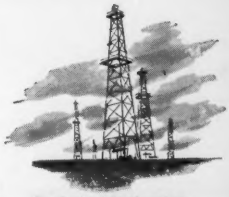
INSTRUMENTS, INC.
115 Cutter Mill Road, Great Neck, New York
Philadelphia • Cleveland • Houston • Miami • Menlo Park, Cal.

"Most models of ZEISS instruments from our stock"



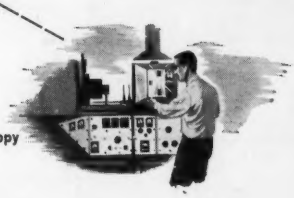
Space Exploration

Military Electronics



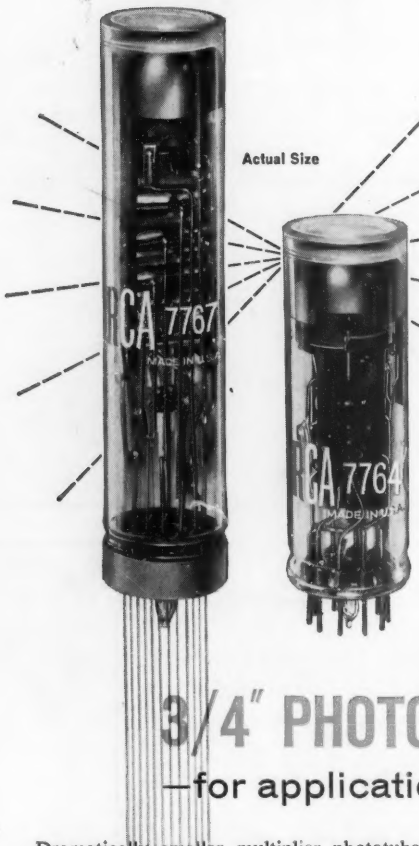
Geological Exploration

Biological Research



Spectroscopy

NEW



Actual Size

3/4" PHOTOMULTIPLIERS

—for applications where space is limited

Dramatically smaller multiplier phototubes with features heretofore found only in the larger types, the new RCA-7764 and -7767 shown here *actual size* offer significant advantages in radiation-detection applications, where *multiplier phototube performance is a must, but where small size is a necessity.*

Variations of these new types can be delivered to you "potted" with a voltage divider designed to meet your specifications. For more information, contact the RCA Field Office nearest you. Or write Marketing Manager, RCA Industrial Products Dept., RCA, Lancaster, Pa. For a free technical bulletin on the RCA-7764 or -7767, write: Section L116-Q, Commercial Engineering, RCA Electron Tube Division, Harrison, N. J.

THE FACTS

Item	RCA-7767	RCA-7764
Stages	10	6
Median Sensitivity (Amperes/lumen)	7.5	0.3
Current Amplification	125,000	5000
Voltage Supply (Volts)	1250	1200
Response Range (Angstroms)	3000-6500 (S11)	3000-6500 (S11)
Max. Response (Angstroms)	Blue 4400	Blue 4400
Max. Rigid Length	4.0"	2.75"
Max. Diameter	0.78"	0.78"

RCA

The Most Trusted Name in Electronics

RADIO CORPORATION OF AMERICA

RCA ELECTRON TUBE DIVISION FIELD OFFICES...Industrial Product Sales: Detroit 2, Michigan, 714 New Center Building, TRinity 5-5600 • Newark 2, N. J., 744 Broad St., HUmboldt 5-3900 • Chicago 54, Illinois, Suite 1154, Merchandise Mart Plaza, WHitehall 4-2900 • Los Angeles 22, Calif., 6355 E. Washington Blvd., RAymond 3-8361 • Burlingame, Calif., 1838 El Camino Real, OXford 7-1620. **Government Sales:** Newark 2, N. J., 744 Broad St. HUmboldt 5-3900 • Dayton 2, Ohio, 224 N. Wilkinson St., BAldwin 6-2366 • Washington 7, D. C., 1725 "K" St., N.W., FEderal 7-8500.